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ABSTRACT

The purpose of the research described in the report is twofold. First, it is to analyze the relative benefits and costs of on-line computerized placement systems. The techniques developed for such an analysis which might be useful in evaluating other manpower programs are presented. Second, it is to provide a prototype model which shows how Employment Service planners and managers could use simulation to better utilize human and machine resources in the placement activity. The demonstration is accomplished in two steps. First, the local office and the placement process are modeled, that is, the underlying dynamics of the system are described. Second, the model is used as the basis for computer simulation of placement-related Employment Service office activity. Recommendations for the use of the tool and for further development are also presented. An example of simulation output and a discussion of random number generation are appended. (Author)

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Report DLMA 21-26-74-21-2

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A STUDY OF ON-LINE USE OF JOB INFORMATION IN EMPLOYEMNT SERVICE LOCAL OFFICES

Volume II: A Simulation Study

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Prepared for

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the Institute of Labor and Industrial Relations, The University of Michigan-Wayne State University.

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This report is available in two volumes. Volume I describes an on-line job matching experiment in Boulder, Colorado, which collected information of placements, referrals and duration of jobs referred by an on-line system versus other means. Volume II describes the simulation of computerized job matching modeled after the activity in Salt Lake City, Utah.

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The purpose of this research is twofold. First, it is to analyze the relative benefits and costs of on-line computerized placement systems. Techniques developed for this analysis are presented; they might be useful in evaluating other manpower programs.

Second, it is to provide a prototype model which shows how Employment Service planners and managers could use simulation to better utilize human and machine resources in the placement activity. This prototype demonstrates the pretesting of management decisions. The demonstration is accomplished in two steps. First, the local office and the placement process are modeled; i.e., the underlying dynamics of the system are described. Second, the model is used as the basis for computer simulation of placement-related Employment Service office activity. Recommendations for the use of this tool and for further development are also presented.

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CHAPTER ONE

INTRODUCTION

The manager of an Employment Service office has two reasons to be concerned with efficiency.

1) He operates on a fixed budget and cannot increase services unless he increases productivity.
2) He provides vital services to large numbers of the American public and should be concerned with getting the most out of each tax dollar spent.

Efficient resource utilization is any manager's primary concern, and he has two basic resources with which to work: people and machines.

To determine the most efficient use of these resources, he has to be aware of several factors. These factors include the functions of all office staff; the activities through which applicants normally proceed; the processes used by applicants who bypass normal procedures; and the use of machines, i.e., who uses which machine, when, and for what purpose.

When he has identified these factors, the manager should identify the relationships between them and ask himself what consequences reallocating his resources might have.

1) How would reducing the number of receptionists from two to one affect the length of time the average applicant waited in line for initial processing?
2) How much interview time would be saved through the introduction of another terminal or microfiche reader?
3) If one interviewer were transferred from serving non-veterans to serving veterans only, how would that affect the average time a non-veteran must wait to see an interviewer?
4) By how much would an extra terminal decrease the time interviewers must wait for a terminal?

5) At what time must the front doors be closed to ensure that everyone in line is served by 5:00 p.m.?

Obviously, any resource allocation decision will have numerous effects on staff and on services provided; and certainly, it is possible for a manager to sit down and diagram all of these interrelationships and work out most of the consequences of changes in staff or machine utilization mathematically. It would be a laborious and time-consuming task, a task which the manager is unlikely to have time to perform. Instead, he may be forced to make an educated guess, a seat-of-the-pants decision based on limited information and made without knowing what the full impact of the decision will be until well after it has been implemented.

Two modeling techniques used in management science can help the manager make more informed decisions: queuing theory and simulation. Both techniques begin with a model. A model is a description of the dynamic process underlying the behavior of an individual or system.[1]

Queuing theory is the study of waiting-line phenomena. It uses applied probability models and predicts behavior by solving mathematical equations. Employment Service offices are too complex for the application of queuing theory to be practical.

Simulation is a method of evaluation in which one course of action is examined in terms of its probable implications for the system under study.[2] Because of the high speed of computers, a number of local office activities can be "acted out" in a short time in order to simulate the effects of decisions.

Modeling and simulation can enable the manager to perform a detailed study and analysis with a reasonable expenditure of time and effort. He can look at a substantial number, if not all, of the parameters of the problem and try out various resource allocation decisions to see their effects before they are implemented.

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[1] R.M. Cyert, "A Description and Evaluation of Some Firm Simulations," Proceedings, IBM Scientific Computing Symposium, Simulation Models and Gaming, White Plains, New York: IBM, 1966

[2] Ibid.

Two basic models are necessary: descriptive and simulation. The descriptive model indicates the placement activities of an Employment Service local office, the priorities placed on these activities, and the relationships between them. Such a descriptive model would be useful to a manager by itself, as it describes the primary factors in his resource allocation problems. Even if he chose to make decisions based on his own calculations, it would clarify the factors under consideration.

The simulation model adds statistics-gathering functions to the descriptive model to monitor the behavior of the model system. Certain variables may be eliminated from the simulation and certain assumptions built into it to keep it inexpensive and manageable.

This simulation model represents the behavior of an Employment Service local office during an entire day of operation, in accordance with well-defined parameters established in the descriptive model. A simulation using this model can run through a number of days, or weeks, of activity, generating information and statistics on average waiting times of applicants at various stages and on the time staff members spend at various functions.

By changing one or more of the factors in the model — the number of interviewers, the number of terminals, or the average amount of time the office is willing to devote to an interview -- the manager can see the effect of changes on other factors, such as the average time an applicant must wait to see an interviewer or the number of people who will be left in line when the office closes. The manager is then in a position to make a more informed choice between alternative resource allocations.

This report is organized into six chapters and two appendixes. Chapter 2 describes the functions and flows of the local Employment Service office being modeled. Chapter 3 describes the nature and assumptions of the simulation model; a non-technical reader may wish to skip this chapter. Chapter 4 describes how such a model can be used. Chapter 5 describes a time study carried out to

obtain data for the simulation. Chapter 6 makes recommendations and draws conclusions. Appendix A is an example simulation output. Appendix B discusses some problems in random number generation.

CHAPTER TWO

THE DESCRIPTIVE MODEL

Assumptions

The descriptive model reduces the Employment Service office to a series of activities. Assumptions are made about the operation of the office; they reduce reality to a series of flows.

The first assumption is that there are three activities in the local office:

1) Taking job orders.
2) Processing applicants.
3) Miscellaneous (measured in one minute intervals).

The second assumption is that these activities are listed in order of priority, i.e., activity one is performed before two; and activity two, before three. When an employment officer finishes one task, he turns to the highest priority task at hand. However, the fact that taking job orders is the highest priority activity does not mean that the employment officer will drop a lower-priority task to take one. He will complete the task on which he is working first.

Unemployment Insurance functions of the local office are ignored. The model contains placement functions only. The office being described is similar to the Salt Lake City local office, but the model can be modified to represent different local offices. (See chapter 6 for a discussion of the modeling and simulation of the widest possible range of office types.) In order to suggest a wider applicability of the model to other offices and to simplify the model for exposition, some activities of the Salt Lake office are not represented. In addition, a model must simplify some local office functions in order to derive meaningful results about other functions.

Job Orders

When a job order call comes into the office, the first available employment officer takes the call.

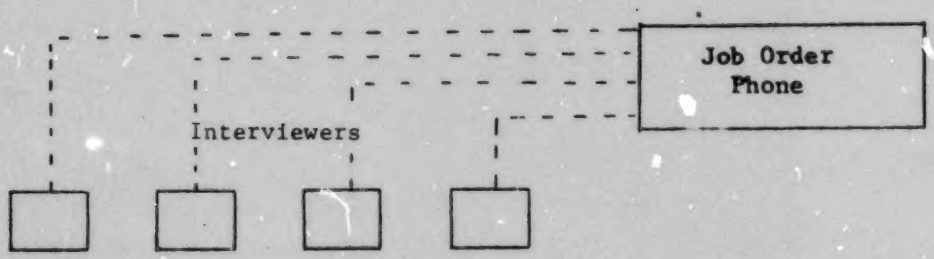

FIGURE 1. JOB ORDER FLOW.

Job Order Parameters

1) Number of job orders received each day (which probably varies for time of day, day of the week, time of the month, and month of the year).
2) Average length of time taken to handle a job order call.

The Interview Process

The standard procedure an applicant goes through when arriving for an interview follows.

1) The applicant arrives and waits in line to see the receptionist.
2) When he reaches the head of the line, the receptionist asks him if he has been registered at the placement center.
3) If the answer is yes, the receptionist asks the applicant's Social Security number, goes to a terminal and enters the number to make sure a valid registration exists.

3a) If the answer is no, the receptionist gives the new applicant a form; he takes the form to another [carousel][1] room, fills it out, and returns.

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[1] The carousel room has an automatic carousel slide/tape recorder presentation, which is used to guide applicants in filling out the application card.

4) At this point, some of the old applicants may check jobs posted on the Job Information Service (JIS) boards, where jobs are organized by occupational groups. Then the applicants return to the front desk.
5) The receptionist enters the applicant's name on the waiting list for interviews.
6) When the applicant's name reaches the top of the list, he is called for the interview.
7) The applicant is interviewed.
8) The interviewer goes to the terminal and waits to use it.
9) The interviewer reports the results of the terminal job search to the applicant.

Interview Parameters

1) Average length of time it takes a receptionist to go to a terminal and perform a registration check, excluding waiting time for terminal.
2) Arrival rate of applicants and ratio of new applicants to old.
3) Average length of time to fill out new applicant forms.
4) Number of persons in each type of staff position during each hour of the day.
5) Average length of time an applicant spends using job display facilities.
6) Average length of time the receptionist spends with an applicant.
7) Average length of interviews.
8) Length of time required to perform a computer-aided job search, exluding waiting time for terminal.

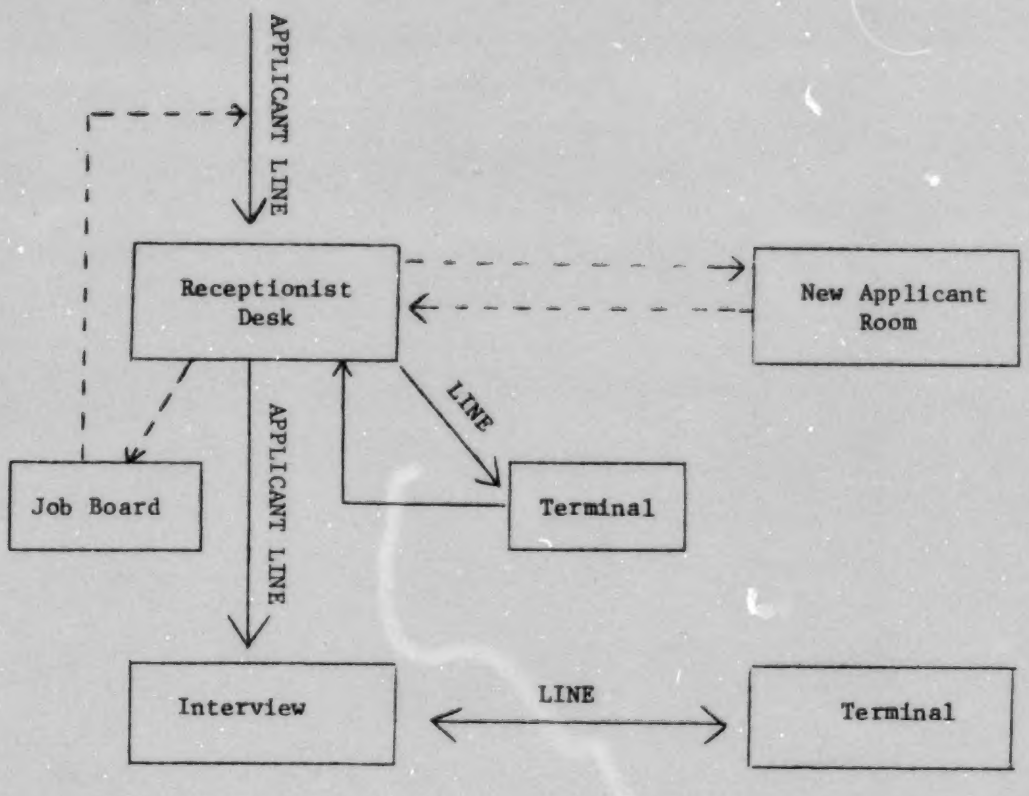

FIGURE 2. STANDARD PROCESS.

The Non-Standard Process

Of course, some applicants by-pass the standard process, particularly those who have been through the interviewing process before, and may either check the job board and then proceed through the standard process or check the board and, finding nothing of interest, leave.

Non-Standard Parameters

1) Percentage of non-standard applicants.
2) Length of time spent at job boards.

Superimposing the non-standard process on the standard process above, the following, more complete process emerges.

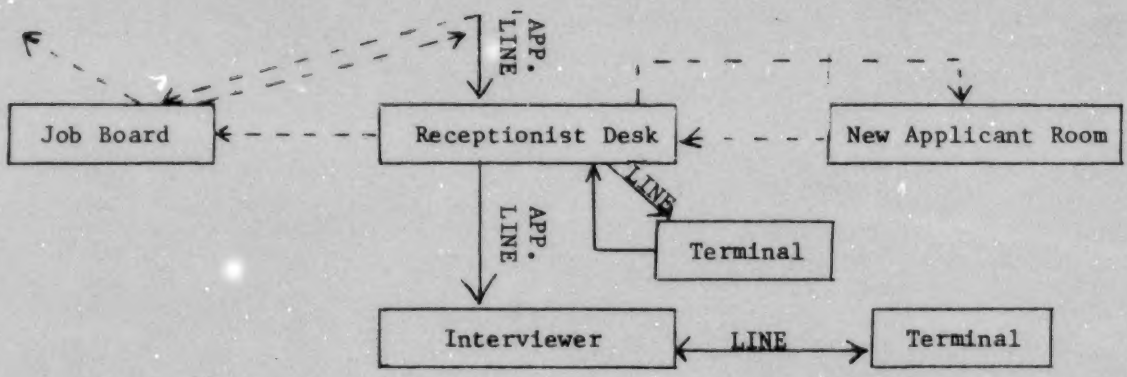

FIGURE 3. MORE COMPLETE PROCESS.

Assumptions/Extensions

This model makes many assumptions which, if relaxed, would extend the model to describe different offices. Some of the more common office variations which could be included are noted here.

There is no clustering in this model. It assumes that all employment officers provide the same services to all applicants. No preference is given to veterans or minority group members in terms of waiting for services, nor does it distinguish between applicants by occupation. It assumes that any person who comes to the receptionist's desk wishes some service(s) from the placement center (the receptionist does not handle Unemployment Insurance claimants).

There is no clustering of terminals. If no terminals are free, all receptionists and employment officers who need to use a terminal stand in the same, single queue waiting for the first available terminal.

Miscellaneous Work

Miscellaneous work is measured in 1 minute intervals and is assumed to occupy staff members when they are not performing higher priority jobs. Filling out reports is an example of miscellaneous work.

CHAPTER THREE

THE SIMULATION OF THE DESCRIPTIVE MODEL

The simulation is based on a mathematical model conforming to the rules set out in the descriptive model. Following these rules, the simulation "steps through" a day at the local office, i.e., applicants are interviewed, job orders are taken, etc. During the course of the simulation, statistics on system behavior — number of people waiting to be interviewed, average length of an interview, staff utilization, etc., -- are gathered and used to generate the reports describing system behavior. Data are generated in the model for each hour in a given day.

Job Orders

Taking job orders is the employment officer's highest priority activity. When a job order call comes in, it is placed last on the job order "queue". The first employment officer to complete his current task takes the first call on the job order queue. The time required to handle the call is simulated by a uniformly distributed random variable whose mean and standard deviation are stipulated by the user of the simulation to reflect the length of job order calls in his office.

When the simulation begins, one job order is waiting to be handled.

The Interview Process

The interview process is diagrammed in Figure 4. When the simulated day begins, there are five old applicants and three new applicants waiting for the door to be opened. "Old" applicants are defined as applicants who have previously been interviewed and therefore have an active registration on file. The interarrival times for both old and new applicants are exponentially distributed. Both means are supplied by the user and, like all other input parameters, can be independently specified for each hour of the working day.

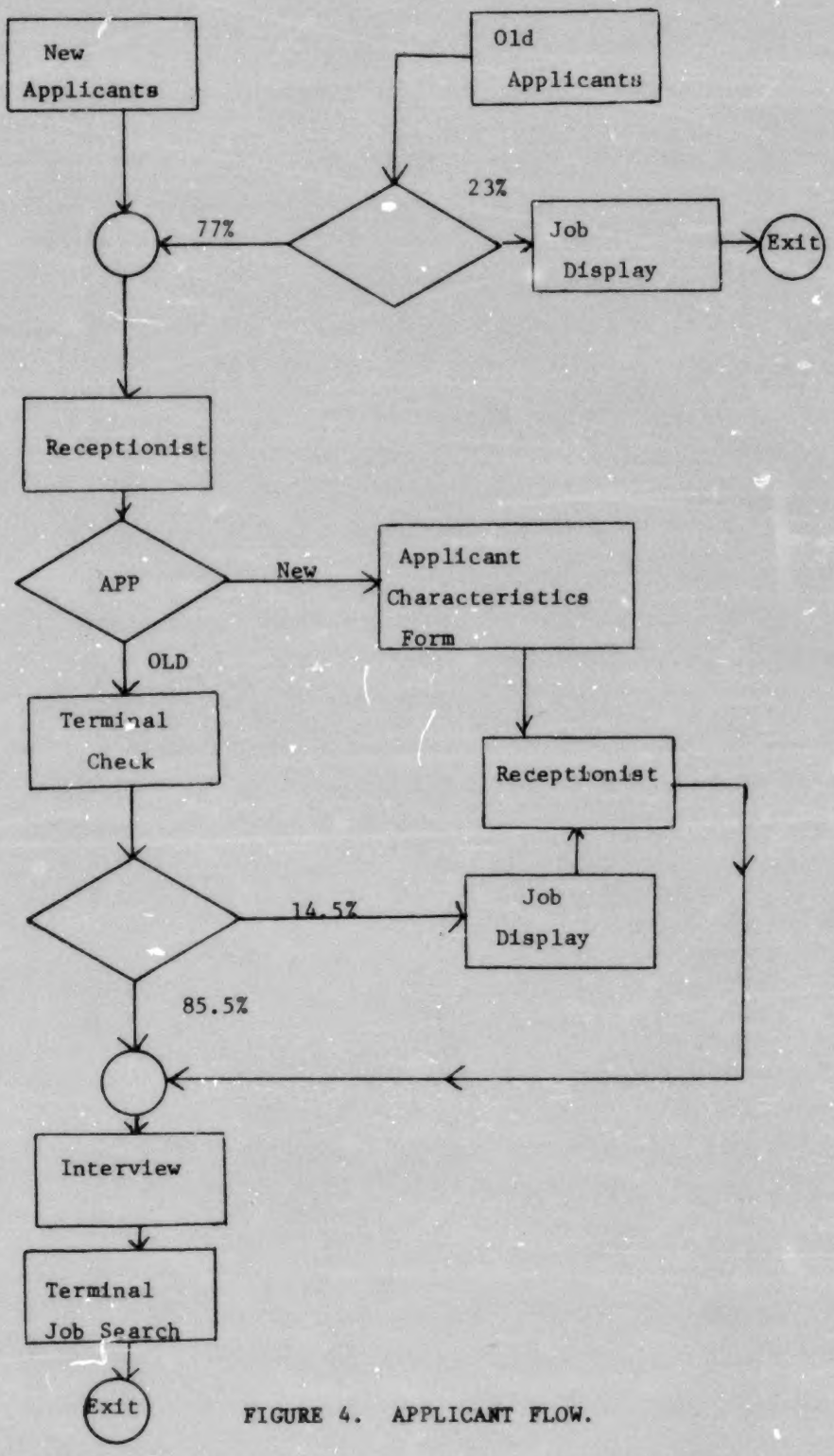

FIGURE 4. APPLICANT FLOW.

Twenty-three percent of the old applicants go immediately to the job display area without stopping at the receptionist's desk.[1] The simulation treats the job display area as a service facility with a limited capacity; but since the descriptive model represents the job display area as a bulletin board, the capacity chosen was large enough to be effectively unlimited. On the other hand, a job display system using microfiche could be simulated simply by setting that capacity to the number of microfiche readers available to applicants. Applicants who go directly to the job display area and are unsuccessful in their job search leave the office and do not require any additional resources. The time they spend at the boards is uniformly distributed with mean and standard deviation specified by the user. When this time has elapsed, they exit the system.

The remaining 77 percent of the old applicants go to the receptionist's desk. When each reaches the head of the line, he gives the receptionist his Social Security number and his name. The time for this interaction, exclusive of any waiting time, is an exponentially distributed random variable with the mean stipulated by the user. The receptionist then goes to an available terminal and enters the applicant's Social Security number to check for a valid registration. The time required for this check is a uniformly distributed random variable with mean and standard deviation specified by the user. After their registration has been checked, most old applicants go immediately to the interview waiting area.

Some (14.5 percent) go to the job display area. The length of time they spend at the boards is uniformly distributed with the mean and standard deviation set by the user.

When they finish at the boards, they return to check in at the receptionist's desk. They are placed on the end of the interview list and proceed to the interview waiting area.

All new applicants go the receptionist's desk immediately on entering the office. The time necessary for their interactions with the receptionist is exponentially distributed with the same mean as

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[1] Data was estimated from a time study conducted at the Salt Lake City placement center.

the interactions of old applicants. They are then routed to a separate area, possibly a carousel room, where they fill out the applicant characteristics forms. Twenty minutes later, they return to the front desk to be placed on the interview list and join the other applicants waiting to be interviewed.

When an interviewer completes his current task, he begins interviewing the applicant at the top of the interview list, assuming there is an applicant waiting and no job order calls are waiting. The time required for their discussion is taken from a user-described uniform distribution.

After the discussion, the employment officer gets in line (if any) to use a terminal. When a terminal is free, he performs an on-line, computer-aided job search. The time required for the job search is taken from a user-described uniform distribution. The results are given to the applicant, and he exits the system.

Miscellaneous Tasks

Miscellaneous includes all other free time. It is performed by employment officers when there are no job orders to process or applicants to interview. In the simulation, miscellaneous tasks are divided into one minute intervals. The time required for a task is taken from a uniform distribution described by the user. If actual low-priority tasks exist, the times required to perform them could be specified in this distribution.

Deriving the Simulation Input

The method the user chooses to determine these parameters and, consequently, the cost of obtaining their values, will depend largely on the purpose for which the simulation is to be used. Suppose the manager simply wanted to get a better understanding of the way the office might function if some minor changes were made. In such a case, he would not need a high degree of accuracy from the simulation and would not need to painstakingly determine the input parameters. It might be sufficient for him to estimate their values from his own

experience.

When a high degree of accuracy is needed, e.g., if the simulation is being used to develop budget estimates, a time study may be necessary. A detailed descriptive model of the proposed office configuration should be developed prior to conducting the time study, which can then be designed to gather the data necessary to both estimate the model's input parameters and validate the proposed model. The time study might collect sample values of the time required to perform an interview, for example. Several models might be proposed initially and data from a time study used to determine which model most closely represents the office. For example, one model might assume that the length of time required for an interview depends on the applicant's occupation and a second model would not contain that assumption. Data from a time study could be used to test that assumption statistically. (An example of such a test appears in Chapter 5.)

In some cases, it is not possible to achieve the level of accuracy afforded by the time study. If the proposed office configuration is sufficiently different from the present office configuration, a time study may not be possible. Such would be the case if a totally new technique were used in the office, e.g., if computer-aided job searches were being used for the first time in any office. In such cases, the manager would have to use the best predictive technique available, knowing that the accuracy of the simulation is limited by the accuracy of the predictive technique used to estimate the input parameters.

Methods used to determine input parameters vary in terms of accuracy and cost. The manager will have to decide what degree of accuracy is required and how much effort he is willing to expend to get it.

Simulation Reports

After the simulation has "stepped through" a local office day, statistics are available for report generation. The following reports can be requested:

1) Input Report
2) Applicant Report
3) Receptionist Facility Report
4) Receptionist Queue Report
5) Employment Office Facility Report
6) Interview Queue Report
7) Terminal Facility Report
8) Terminal Queue Report
9) Job Order Queue Report

Input Report

The Input Report prints the input parameters supplied by the user for the current simulation run. This report includes the parameters (in minutes) for the statistical distributions previously discussed and the staff level. This report appears in Table 1. The letters in square brackets indicate references to various sections of the displayed report.

To determine arrival rates of new and old applicants in the simulation, the user specifies the mean (average) time between two consecutive arrivals. Since the interarrival times of applicants are exponentially distributed, only the mean time need be specified for each hour of the day and each applicant type. The job order interarrival times are uniformly distributed over the interval specified by the user [A].

The length of time required to perform various activities in the simulation are also taken from distributions whose parameters are supplied by the user. The amount of time required for the receptionist to question an applicant [B] is taken from an exponential distribution; the mean time is the only parameter supplied by the user. Times for the remaining activities are uniformly distributed over intervals supplied by the user. In order of their appearance in the Input Report, these activities are:

1) The applicant's interview with an employment officer [C].

2) The search of the job boards by an applicant who will stay to be interviewed [D].

3) The search of the job boards by an applicant who will leave immediately after scanning the boards without ever going to the receptionist's desk [E].

4) The computer-aided registration check performed by the receptionist [F].

5) The computer-aided job search performed by the employment officer [G].

6) The handling of a job order call by an employment officer [H].

7) The miscellaneous task that occupies the employment officer's slack time [I].

The last item in the Input Report shows the number of receptionists and employment officers working each hour and the number of computer terminals available to them [J].

TABLE 1. INPUT REPORT

****
* INPUT REPORT *
****

[A]
ARRIVAL RATES

HOUR	NEW APPS MEAN	OLD APPS MEAN	JOB ORDER FROM	JOB ORDER TO
8	1.824	0.949	0.0	20.000
9	1.749	0.840	0.0	20.000
10	0.926	0.553	0.0	20.000
11	1.348	1.025	0.0	20.000
12	1.940	1.577	0.0	20.000
1	1.500	1.160	0.0	20.000
2	4.350	1.406	0.0	20.000
3	1.532	1.720	0.0	20.000
4	6.640	3.720	0.0	20.000

ACTIVITY DURATIONS

HOUR	DISCUSSIONS RECEP [B] MEAN	EMP. OFF.[C] FROM	EMP. OFF.[C] TO	APP JOB SEARCH SUCCESSFUL [D] FROM	SUCCESSFUL [D] TO	UNSUCCESSFUL [E] FROM	UNSUCCESSFUL [E] TO
8	0.300	0.0	19.200	11.600	32.000	15.600	26.700
9	0.300	0.0	19.200	11.600	32.000	15.600	26.700
10	0.300	0.0	19.200	11.600	32.000	15.600	26.700
11	0.300	0.0	19.200	11.600	32.000	15.600	26.700
12	0.300	0.0	19.200	11.600	32.000	15.600	26.700
1	0.300	0.0	19.200	11.600	32.000	15.600	26.700
2	0.300	0.0	19.200	11.600	32.000	15.600	26.700
3	0.300	0.0	19.200	11.600	32.000	15.600	26.700
4	0.300	0.0	19.200	11.600	32.000	15.600	26.700

ACTIVITY DURATIONS

HOUR	TERMINAL USE RECEPTIONIST [F] FROM	TERMINAL USE RECEPTIONIST [F] TO	EMP. OFF. [G] FROM	EMP. OFF. [G] TO	JOBORDER [H] FROM	JOBORDER [H] TO	MISC. TASK [I] FROM	MISC. TASK [I] TO
8	0.250	0.750	0.500	2.500	0.0	4.000	1.000	1.000
9	0.250	0.750	0.500	2.500	0.0	4.000	1.000	1.000
10	0.250	0.750	0.500	2.500	0.0	4.000	1.000	1.000
11	0.250	0.750	0.500	2.500	0.0	4.000	1.000	1.000
12	0.250	0.750	0.500	2.500	0.0	4.000	1.000	1.000
1	0.250	0.750	0.500	2.500	0.0	4.000	1.000	1.000
2	0.250	0.750	0.500	2.500	0.0	4.000	1.000	1.000
3	0.250	0.750	0.500	2.500	0.0	4.000	1.000	1.000
4	0.250	0.750	0.500	2.500	0.0	4.000	1.000	1.000

[J]
CAPACITIES

HOUR	RECEP	EMPOF	TERM
8	3	15	2
9	3	15	2
10	3	15	2
11	3	15	2
12	3	15	2
1	3	15	2
2	3	15	2
3	3	15	2
4	3	15	2

Applicant Report

The Applicant Report provides information about the flow of applicants into the system, the number of applicants in the system during a given period of time, and the amount of time each applicant spends in the system. This report appears in Table 2.

There are two time breakdowns in the report: hourly and full-day summations. For each hour, the report gives two types of statistics: the number of applicants in the system and the amount of time applicants spent in the system. The former gives the number of applicants entering [A] and leaving [E] during an hour with separate figures on old and new applicants, and the minimum [B], maximum [C], and average [D] numbers of applicants in the system during the hour. The "applicant time spent in system" section shows the minimum [F] and maximum [G] amount of time spent in the system by applicants who wait during the hour. The mean [H] and standard deviation [I] can be read together: the average amount of time spent in the system $\pm$ the standard deviation gives the range of times for the majority of applicants. The full-day statistics provide the same statistical breakdowns for the entire day.

TABLE 2. APPLICANTS

		[A]	[B]	[C]	[D]	[E]	[F]	[G]	[H]	[I]
			APPLICANTS IN SYSTEM				APPLICANT TIME SPENT IN SYSTEM			
TIME	CLASS	ARRIVALS	MIN	MAX	AVERAGE	DONE	MIN	MAX	MEAN	STD DEV
8- 9	ALL	97	0	41	29.936	60	3.932	43.608	20.046	10.010
	NEW	37	0	22	14.345	15	24.860	41.892	31.336	5.213
	OLD	43	0	16	11.159	35	3.932	43.608	15.556	8.826
	OTH	17	0	8	4.432	10	11.767	26.071	18.828	5.271
9-10	ALL	86	27	48	36.705	78	5.562	48.17	24.[illegible]9	11.253
	NEW	24	14	22	17.572	28	25.265	44.787	35.952	5.936
	OLD	47	5	25	14.828	34	5.562	48.177	18.820	9.619
	OTH	15	2	7	4.306	16	12.800	26.422	17.548	3.710
10-11	ALL	140	43	91	62.939	95	11.250	60.090	30.816	12.563
	NEW	58	17	51	32.016	26	33.832	56.295	44.790	6.111
	OLD	59	18	38	23.534	47	15.087	60.090	28.394	10.640
	OTH	23	4	12	7.390	22	11.250	24.855	19.478	4.945
11-12	ALL	90	87	106	96.868	80	11.423	84.972	45.682	21.002
	NEW	31	47	58	52.660	32	45.946	84.269	65.248	11.222
	OLD	44	33	45	39.738	32	26.160	84.972	40.654	11.399
	OTH	15	2	7	4.471	16	11.423	26.075	16.605	4.661
12- 1	ALL	62	88	100	91.945	71	11.148	114.102	72.029	26.686
	NEW	21	39	51	46.464	31	81.768	103.480	92.854	6.974
	OLD	33	37	49	43.235	31	50.701	114.102	66.917	15.831
	OTH	8	0	6	2.247	9	11.148	25.682	17.909	5.648
1- 2	ALL	99	88	119	100.056	75	11.950	117.874	80.068	31.015
	NEW	35	37	48	42.943	29	90.157	114.335	102.434	6.793
	OLD	55	44	70	53.900	34	60.912	117.874	82.535	17.644
	OTH	9	0	6	3.214	12	11.950	24.038	19.033	4.273
2- 3	ALL	63	104	119	112.725	73	16.317	113.000	76.923	21.914
	NEW	17	41	48	44.151	20	83.332	107.795	95.227	6.319
	OLD	36	58	71	65.495	46	62.281	113.000	77.482	10.622
	OTH	10	1	5	3.081	7	16.317	24.468	20.947	3.863
3- 4	ALL	63	92	107	102.397	72	12.090	133.710	88.221	32.504
	NEW	38	42	59	49.8[illegible]	22	91.248	124.907	110.103	9.484
	OLD	15	33	58	48.857	39	73.664	133.710	95.256	15.037
	OTH	10	1	5	3.710	11	12.090	25.626	19.514	3.730
4- 5	ALL	26	50	97	72.770	72	11.200	139.954	95.029	30.555
	NEW	8	29	58	47.110	37	86.604	139.954	110.696	14.549
	OLD	13	18	35	24.258	28	70.889	129.036	93.623	16.764
	OTH	5	0	4	1.402	7	11.200	26.167	17.840	6.223
8-5	ALL	726	0	119	78.482	676	11.200	139.954	58.640	35.659
8-5	NEW	269	0	59	38.566	240	24.860	139.954	79.170	30.834
8-5	OLD	345	0	71	36.111	326	3.932	133.710	57.058	32.808
8-5	OTH	112	0	12	3.806	110	11.148	26.422	18.536	4.663

Receptionist Facility Report

The Receptionist Facility Report provides statistics for the receptionists' functions. Again, there are two time breakdowns in the report: hour and full day. The staff level for each hour is generated from the input provided. The average staff utilization figure [A] ranges from 0.0 (idle) to 1.0 (always busy). The number of applicants served [B] gives the average number of applicants being served at any one time, the maximum number being served at any one time [C], and the total number of applicants served during that hour [D]. Statistics are also provided for the average amount of time taken by each transaction or applicant/receptionist activity [E], and the standard deviation [F]. The full-day summation provides the same statistics and also includes the number of 8-hour man-days worked during the 9-hour day. This report appears in Table 3.

TABLE 3. RECEPTIONIST FACILITY

RECEPTIONIST FACILITY

TIME	STAFF LEVEL	ACTIVITY	[A] AVG STAFF UTILIZATION	[B] NO. OF TRANSACTION AVG	[C] MAX	[D] TOTAL	[E] TIME PER TRANSACTION MEAN	[F] STD DEV
8- 9	3	RECEPTION	0.503	1.510	3	67	1.080	1.023
		ENCOUNTER	0.191	0.572	3	105	0.327	0.338
		TERM WAIT	0.197	0.592	3	22	1.616	0.945
		COMPUTER	0.115	0.345	2	42	0.490	0.148
		MISC.	0.497					
		HR SUB-TOTAL	1.000					
9-10	3	RECEPTION	0.768	2.304	3	67	1.406	1.374
		ENCOUNTER	0.241	0.722	3	111	0.390	0.428
		TERM WAIT	0.410	1.230	3	40	1.570	1.198
		COMPUTER	0.117	0.352	2	45	0.472	0.153
		MISC.	0.232					
		HR SUB-TOTAL	1.000					
10-11	3	RECEPTION	1.000	3.000	3	84	2.070	1.854
		ENCOUNTER	0.206	0.618	2	134	0.276	0.302
		TERM WAIT	0.660	1.981	3	49	2.621	1.178
		COMPUTER	0.134	0.401	2	48	0.499	0.152
		MISC.	0.0					
		HR SUB-TOTAL	1.000					
11-12	3	RECEPTION	1.000	3.000	3	92	1.862	1.838
		ENCOUNTER	0.201	0.603	3	123	0.295	0.318
		TERM WAIT	0.684	2.052	3	46	2.675	1.339
		COMPUTER	0.115	0.345	2	46	0.451	0.154
		MISC.	0.0					
		HR SUB-TOTAL	1.000					
12- 1	3	RECEPTION	0.840	2.521	3	99	1.417	1.601
		ENCOUNTER	0.187	0.562	3	129	0.262	0.257
		TERM WAIT	0.532	1.597	3	42	2.291	1.207
		COMPUTER	0.121	0.362	2	42	0.518	0.137
		MISC.	0.160					
		HR SUB-TOTAL	1.000					

TABLE 3. Continued

RECEPTIONIST FACILITY

			[A]	[B]	[C]	[D]	[E]	[F]
TIME	STAFF LEVEL	ACTIVITY	AVG STAFF UTILIZATION	NO. OF TRANSACTION AVG	MAX	TOTAL	TIME PER TRANSACTION MEAN	STD DEV
1- 2	3	RECEPTION	0.850	2.551	3	62	2.307	1.770
		ENCOUNTER	0.159	0.476	3	92	0.311	0.253
		TERM WAIT	0.574	1.723	3	41	2.478	1.206
		COMPUTER	0.117	0.352	2	42	0.497	0.158
		MISC.	0.150					
		HR SUB-TOTAL	1.000					
2- 3	3	RECEPTION	1.000	3.000	3	83	2.160	1.846
		ENCOUNTER	0.170	0.511	3	101	0.298	0.245
		TERM WAIT	0.694	2.082	3	46	2.755	1.003
		COMPUTER	0.136	0.407	2	47	0.526	0.145
		MISC.	0.0					
		HR SUB-TOTAL	1.000					
3- 4	3	RECEPTION	0.502	1.507	3	69	1.159	1.606
		ENCOUNTER	0.167	0.502	3	109	0.282	0.262
		TERM WAIT	0.279	0.838	3	18	2.851	1.295
		COMPUTER	0.056	0.167	2	20	0.501	0.154
		MISC.	0.498					
		HR SUB-TOTAL	1.000					
4- 5	3	RECEPTION	0.172	0.516	3	27	1.076	1.128
		ENCOUNTER	0.045	0.134	2	35	0.230	0.190
		TERM WAIT	0.087	0.261	2	11	1.421	0.770
		COMPUTER	0.040	0.121	2	13	0.557	0.092
		MISC.	0.828					
		HR SUB-TOTAL	1.000					
8-5		RECEPTION	0.737	2.212	3	670	1.659	1.676
8-5		ENCOUNTER	0.174	0.522	3	939	0.300	0.304
8-5		TERM WAIT	0.458	1.373	3	315	2.353	1.245
8-5		COMPUTER	0.106	0.317	2	345	0.496	0.149
		MISC.	0.263					
8-5	3.37*	---TOTAL---	1.000					

Receptionist Queue Report

The Receptionist Queue Contents Report gives information about the applicants waiting in line to see a receptionist. The report indicates the number of applicants who have entered the line during that hour [A], the minimum [B], maximum [C], and average number of persons in the line during the hour [D], and the number of persons in the line at the close of the hour[E].

The Queue Waiting Time Report gives information about the length of time applicants spend in line. In includes the minimum (non-zero) [F], and maximum waits [I], the number [G] and percentage of applicants who did not have to wait [H], and the mean and standard deviation times, with [J,K] and without [L,M] zero-length waits, i.e. including and excluding times for applicants who did not have to wait. These reports appear in Table 4.

TABLE 4. RECEPTIONIST QUEUE

****
* RECEPTIONIST QUEUE *
****

	[A]		[B]	[C]	[D]	[E]
	----- QUEUE CONTENTS -----					
TIME	ENTRIES	ENTRIES*	MIN	MAX	AVERAGE	NOW
8- 9	105	34	0	8	0.848	0
9-10	111	62	0	14	2.657	3
10-11	135	135	0	32	15.771	24
11-12	123	123	23	49	34.601	35
12- 1	128	112	0	35	8.999	1
1- 2	92	61	0	34	7.380	34
2- 3	103	103	8	37	24.769	8
3- 4	107	32	0	15	1.616	0
4- 5	0	0	0	0	0.0	0
8-5	904	662	0	49	10.738	

ENTRIES* INCLUDES ONLY NON-ZERO QUEUE TIMES

	[F]	[G]	[H]	[I]	[J]	[K]	[L]	[M]
	----- QUEUE WAITING TIMES -----							
TIME	MIN	ZERO-#	ZERO-%	MAX	MEAN	STD DEV	MEAN*	STD DEV*
8- 9	0.018	71	67.62	2.889	0.485	0.891	1.497	0.970
9-10	0.008	49	44.14	7.710	1.404	2.080	2.513	2.229
10-11	1.013	0	0.0	10.920	6.285	2.446	6.285	2.446
11-12	7.255	0	0.0	20.340	15.389	2.586	15.389	2.586
12- 1	0.058	16	12.50	18.372	6.438	5.466	7.358	5.230
1- 2	0.022	31	33.70	12.296	2.209	3.177	3.331	3.392
2- 3	9.166	0	0.0	20.479	16.399	2.460	16.399	2.460
3- 4	0.132	75	70.09	9.773	1.253	2.591	4.189	3.203
4- 5	0.0	35	100.00	0.0	0.0	0.0	0.0	0.0
8-5	0.0	277	0.0	20.479	6.175	6.590	8.759	6.242

MEAN* AND STD DEV* ARE FOR NON-ZERO TIMES ONLY

Employment Officer Facility Report

The Employment Officer Facility Report provides information about the employment officers' functions. Their duties are broken down into three broad categories: interviewing, handling job orders, and doing miscellaneous work. The interviewing function is further broken down into three component parts: the discussion period with the applicant, the waiting period for the use of a terminal (if any), and the amount of time actually spent interacting with the computer system. Again, the information is given both in hour-by-hour breakdowns and in full-day summations, with an additional hourly subtotal of staff utilization. The report shows the staff levels [A] for each hour and the average staff utilization at each activity [B]. The average number of transactions occurring at any time during the hour [C], the maximum number going on at any one time during the hour [D], and the total number of transactions taking place during the hour [E] are also provided -- again broken down by activity. In addition, the average time per transaction [F] in minutes and the standard deviation [G] from the average are given. Entire-day summations are provided and include the number of 8-hour man-days worked that day [A]. (The simulation was run for a 9-hour day.) This report is displayed in Table 5.

TABLE 5. EMPLOYMENT OFFICER FACILITY REPORT

EMPLOYMENT OFFICER FACILITY

[A] TIME	STAFF LEVEL	ACTIVITY	[B] AVG STAFF UTILIZATION	[C] NO. OF TRANSACTION AVG	[D] MAX	[E] TOTAL	[F] TIME PER TRANSACTION MEAN	[G] STD DEV
8- 9	15	INTERVIEW	0.713	10.697	15	50	10.951	5.923
		DISCUSSION	0.560	8.397	15	56	8.828	5.636
		TERM WAIT	0.071	1.059	7	36	1.427	0.940
		COMPUTER	0.083	1.241	2	50	1.484	0.584
		JOB ORDER	0.014	0.209	1	6	2.094	1.257
		MISC.	0.273	4.093	15	244	1.000	0.0
		HR SUB-TOTAL	1.000					
9-10	15	INTERVIEW	0.879	13.188	15	62	12.145	6.279
		DISCUSSION	0.675	10.131	15	59	8.915	5.945
		TERM WAIT	0.101	1.521	6	55	1.800	1.325
		COMPUTER	0.102	1.537	2	62	1.456	0.624
		JOB ORDER	0.014	0.205	1	7	1.754	1.199
		MISC.	0.107	1.607	7	98	1.000	0.0
		HR SUB-TOTAL	1.000					
10-11	15	INTERVIEW	0.977	14.659	15	73	12.222	5.703
		DISCUSSION	0.668	10.025	14	72	8.319	5.851
		TERM WAIT	0.202	3.036	6	72	2.575	0.999
		COMPUTER	0.107	1.599	2	73	1.337	0.604
		JOB ORDER	0.013	0.191	1	8	1.431	1.085
		MISC.	0.010	0.150	2	9	1.000	0.0
		HR SUB-TOTAL	1.000					
11-12	15	INTERVIEW	0.986	14.783	15	64	13.828	6.012
		DISCUSSION	0.680	10.200	14	66	9.661	5.775
		TERM WAIT	0.196	2.934	7	63	2.762	1.213
		COMPUTER	0.110	1.649	2	64	1.542	0.579
		JOB ORDER	0.014	0.217	1	5	2.606	0.719
		MISC.	0.0	0.0	0	0	0.0	0.0
		HR SUB-TOTAL	1.000					
12- 1	15	INTERVIEW	0.986	14.795	15	62	14.280	5.825
		DISCUSSION	0.724	10.858	15	62	10.753	5.543
		TERM WAIT	0.154	2.315	5	59	2.350	0.968
		COMPUTER	0.108	1.622	2	62	1.565	0.605
		JOB ORDER	0.014	0.205	1	6	2.046	1.407
		MISC.	0.0	0.0	0	0	0.0	0.0
		HR SUB-TOTAL	1.000					

TABLE 5. Continued

EMPLOYMENT OFFICER FACILITY

[A] TIME	STAFF LEVEL	ACTIVITY	[B] AVG STAFF UTILIZATION	[C] NO. OF TRANSACTION AVG	[D] MAX	[E] TOTAL	[F] TIME PER TRANSACTION MEAN	[G] STD DEV
1- 2	15	INTERVIEW	0.988	14.821	15	63	14.434	5.029
		DISCUSSION	0.727	10.908	14	62	10.386	4.710
		TERM WAIT	0.151	2.267	6	63	2.201	1.165
		COMPUTER	0.110	1.645	2	63	1.578	0.495
		JOB ORDER	0.012	0.179	1	6	1.794	1.246
		MISC.	0.0	0.0	0	0	0.0	0.0
		HR SUB-TOTAL	1.000					
2- 3	15	INTERVIEW	0.987	14.809	15	66	13.041	5.560
		DISCUSSION	0.670	10.049	14	69	8.761	5.513
		TERM WAIT	0.211	3.167	8	67	2.817	1.080
		COMPUTER	0.106	1.593	2	66	1.427	0.571
		JOB ORDER	0.013	0.191	2	5	2.296	1.501
		MISC.	0.0	0.0	0	0	0.0	0.0
		HR SUB-TOTAL	1.000					
3- 4	15	INTERVIEW	0.986	14.793	15	61	14.980	5.953
		DISCUSSION	0.719	10.781	15	55	10.964	5.731
		TERM WAIT	0.159	2.385	7	56	2.613	1.592
		COMPUTER	0.108	1.627	2	61	1.628	0.605
		JOB ORDER	0.014	0.207	1	5	2.481	0.812
		MISC.	0.0	0.0	0	0	0.0	0.0
		HR SUB-TOTAL	1.000					
4- 5	15	INTERVIEW	0.987	14.805	15	65	13.673	5.624
		DISCUSSION	0.777	11.657	15	68	10.737	5.663
		TERM WAIT	0.091	1.364	5	54	1.509	0.820
		COMPUTER	0.119	1.784	2	65	1.627	0.592
		JOB ORDER	0.013	0.195	1	10	1.168	1.137
		MISC.	0.0	0.0	0	0	0.0	0.0
		HR SUB-TOTAL	1.000					
8-5		INTERVIEW	0.943	14.150	15	566	13.314	5.849
8-5		DISCUSSION	0.689	10.334	15	569	9.675	5.652
8-5		TERM WAIT	0.148	2.227	8	525	2.290	1.233
8-5		COMPUTER	0.106	1.589	2	566	1.513	0.589
8-5		JOB ORDER	0.013	0.200	2	58	1.861	1.187
8-5		MISC.	0.043	0.650	15	351	1.000	0.001
8-5	16.87*	---TOTAL---	1.000					

* - AVERAGE STAFF LEVEL IS IN 8-HOUR MAN DAYS

Interview Queue Report

The Interview Queue Report consists of two parts.

The Contents Report indicates, by hour and for a full-day summary, the number of applicants entering the line to see an interviewer during each hour [A]. It also gives the average [D], minimum [B], and maximum [C] number of persons in the line during the hour, and the number of persons in the line at the end of the hour [E].

The Queue Waiting Times Report shows the length of time applicants waited to see an interviewer. It includes the minimum [F] (non-zero) and maximum times waited [I], the number [G] and percent [H] of applicants who did not have to wait, and the mean and standard deviation times, both including [J,K] and exluding [L,M] zero-length waits. See Table 6 for these reports.

TABLE 6. INTERVIEWER QUEUE

= INTERVIEW QUEUE =

	[A]		[B]	[C]	[D]	[E]
	----- QUEUE CONTENTS -----					
TIME	ENTRIES	ENTRIES*	MIN	MAX	AVERAGE	NOW
8- 9	60	60	0	3	0.446	0
9-10	67	67	0	13	1.668	9
10-11	73	73	0	14	5.065	13
11-12	64	64	11	34	23.729	29
12- 1	62	62	29	68	51.305	62
1- 2	63	63	53	63	58.771	53
2- 3	66	66	51	68	59.556	63
3- 4	61	61	59	73	65.926	66
4- 5	65	65	28	67	51.593	28
8-5	581	581	0	73	35.340	

ENTRIES* INCLUDES ONLY NON-ZERO QUEUE TIMES

	[F]	[G]	[H]	[I]	[J]	[K]	[L]	[M]
	----- QUEUE WAITING TIMES -----							
TIME	MIN	ZERO-#	ZERO-%	MAX	MEAN	STD DEV	MEAN*	STD DEV*
8- 9	0.001	0	0.0	3.172	0.446	0.587	0.446	0.587
9-10	0.003	0	0.0	5.651	0.873	1.316	0.873	1.316
10-11	0.151	0	0.0	9.961	4.032	2.836	4.082	2.836
11-12	7.324	0	0.0	30.572	17.209	6.523	17.209	6.523
12- 1	22.163	0	0.0	43.381	31.528	6.138	31.528	6.138
1- 2	43.700	0	0.0	64.778	54.679	5.173	54.679	5.173
2- 3	45.157	0	0.0	60.242	53.904	4.489	53.904	4.489
3- 4	50.049	0	0.0	63.150	57.565	3.385	57.565	3.385
4- 5	57.630	0	0.0	67.295	63.125	2.482	63.125	2.482
8-5	0.001	0	0.0	67.295	31.078	25.316	31.078	25.316

MEAN* AND STD DEV* ARE FOR NON-ZERO TIMES ONLY

Terminal Facility Report

The Terminal Facility Report provides information about the utilization of the computer terminals. Information is given in an hour-by-hour breakdown and in full-day summation; the report shows the number of terminal units present and the average length of time they are in use during each hour [A] with further breakdowns of utilization by employment officers and receptionists. It provides the average [B] and maximum [C] numbers of transactions occurring at any one time during the hour and the total number of transactions [D] taking place during the hour. In addition, the minimum [E], maximum [F], mean [G], and standard deviation [H] are shown in minutes for the amount of time per transaction. This report appears in Table 7.

TABLE 7. TERMINAL FACILITY REPORT

TERMINAL FACILITY

			[A]	[B]	[C]	[D]	[E]	[F]	[G]	[H]
			AVERAGE	NO. OF TRANSACTIONS			TIME PER TRANSACTION			
TIME	UNITS	USERS	UTILIZATION	AVG	MAX	TOTAL	MIN	MAX	MEAN	STD DEV
8- 9	2	ALL USER	0.793	1.587	2	92	0.257	2.464	1.031	0.664
		EMPOP	0.621	1.241	2	50	0.519	2.464	1.484	0.584
		RECEP	0.173	0.345	2	42	0.257	0.741	0.490	0.148
		FREE	0.207							
9-10	2	ALL USER	0.944	1.889	2	107	0.252	2.495	1.042	0.687
		EMPOP	0.768	1.537	2	62	0.506	2.495	1.456	0.624
		RECEP	0.176	0.352	2	45	0.252	0.730	0.472	0.153
		FREE	0.056							
10-11	2	ALL USER	1.000	2.000	2	121	0.253	2.417	1.005	0.630
		EMPOP	0.799	1.599	2	73	0.500	2.417	1.337	0.604
		RECEP	0.201	0.401	2	48	0.253	0.749	0.499	0.152
		FREE	0.0							
11-12	2	ALL USER	0.997	1.994	2	110	0.250	2.415	1.086	0.704
		EMPOP	0.824	1.649	2	64	0.512	2.415	1.542	0.579
		RECEP	0.173	0.345	2	46	0.250	0.729	0.451	0.154
		FREE	0.003							
12- 1	2	ALL USER	0.992	1.984	2	104	0.253	2.450	1.142	0.701
		EMPOP	0.811	1.622	2	62	0.507	2.450	1.565	0.605
		RECEP	0.181	0.362	2	42	0.253	0.726	0.518	0.137
		FREE	0.008							
1- 2	2	ALL USER	0.999	1.997	2	105	0.252	2.365	1.146	0.663
		EMPOP	0.823	1.645	2	63	0.520	2.365	1.578	0.496
		RECEP	0.176	0.352	2	42	0.252	0.729	0.497	0.158
		FREE	0.001							
2- 3	2	ALL USER	1.000	2.000	2	113	0.289	2.490	1.052	0.630
		EMPOP	0.796	1.593	2	66	0.522	2.490	1.427	0.571
		RECEP	0.204	0.407	2	47	0.289	0.738	0.526	0.145
		FREE	0.0							
3- 4	2	ALL USER	0.897	1.794	2	81	0.263	2.477	1.350	0.721
		EMPOP	0.814	1.627	2	61	0.507	2.477	1.628	0.605
		RECEP	0.084	0.167	2	20	0.263	0.716	0.501	0.154
		FREE	0.103							
4- 5	2	ALL USER	0.952	1.905	2	78	0.434	2.486	1.549	0.674
		EMPOP	0.892	1.784	2	65	0.631	2.486	1.627	0.592
		RECEP	0.060	0.121	2	13	0.434	0.712	0.557	0.092
		FREE	0.048							
8-5	2	ALL USER	0.953	1.906	2	911	0.250	2.495	1.128	0.684
8-5	2	EMPOP	0.794	1.589	2	566	0.500	2.495	1.513	0.589
8-5	2	RECEP	0.158	0.317	2	345	0.250	0.749	0.496	0.149
8-5	2	FREE	0.047							

Terminal Queue Report

The Terminal Queue Contents Report gives hourly and full-day summary statistics on the number of staff members waiting for or using terminals. Statistics are given for all staff members, receptionists only, and employment officers only. Statistics include the number who used a terminal [A], the number who waited in line before using a terminal [B], and the minimum [C], maximum [D], average [E], and current number in the terminal queue at the end of the hour [F].

The Terminal Queue Waiting Times portion of this report gives the same hourly and summary breakdowns on the minimum [G] and maximum [J] waiting times, the number [H] and percent [I] of the terminal users who did not have to wait, and the mean and standard deviation of the waiting times both including [K,L] and excluding [M,N] times for users who did not have to wait. See Table 8 for these reports.

TABLE 8. TERMINAL QUEUE REPORT

****
* TERMINAL QUEUE *
****

		[A]	[B]	[C]	[D]	[E]	[F]
		----- QUEUE CONTENTS -----					
TIME	USERS	ENTRIES	ENTRIES*	MIN	MAX	AVERAGE	NOW
8- 9	ALL USER	94	58	0	9	1.651	5
	EMPOP	51	36	0	7	1.059	5
	RECEP	43	22	0	3	0.592	0
9-10	ALL USER	107	95	0	8	2.751	4
	EMPOP	63	55	0	6	1.521	1
	RECEP	44	40	0	3	1.230	3
10-11	ALL USER	121	121	1	8	5.016	2
	EMPOP	72	72	0	6	3.036	1
	RECEP	49	49	0	3	1.981	1
11-12	ALL USER	110	109	0	9	4.985	4
	EMPOP	64	63	0	7	2.934	3
	RECEP	46	46	0	3	2.052	1
12- 1	ALL USER	104	101	0	8	3.912	5
	EMPOP	62	59	0	5	2.315	3
	RECEP	42	42	0	3	1.597	2
1- 2	ALL USER	105	104	0	8	3.991	4
	EMPOP	63	63	0	6	2.267	2
	RECEP	42	41	0	3	1.723	2
2- 3	ALL USER	113	113	0	10	5.249	5
	EMPOP	67	67	0	8	3.167	4
	RECEP	46	46	0	3	2.082	1
3- 4	ALL USER	79	74	0	9	3.223	0
	EMPOP	59	56	0	7	2.385	0
	RECEP	20	18	0	3	0.838	0
4- 5	ALL USER	80	65	0	5	1.624	1
	EMPOP	67	54	0	5	1.364	1
	RECEP	13	11	0	2	0.261	0
8-5	ALL USER	913	840	0	10	3.600	
8-5	EMPOP	568	525	0	8	2.227	
8-5	RECEP	345	315	0	3	1.373	

ENTRIES* INCLUDES ONLY NON-ZERO QUEUE TIMES

TABLE 8. Continued

		[G]	[H]	[I]	[J]	[K]	[L]	[M]	[N]
		----- QUEUE WAITING TIMES -----							
TIME	USER	MIN	ZERO-#	ZERO-%	MAX	MEAN	STD DEV	MEAN*	STD DEV*
8- 9	ALL USER	0.033	36	38.30	3.923	0.925	1.038	1.499	0.939
	EMPOF	0.122	15	29.41	3.923	1.008	1.025	1.427	0.940
	RECEP	0.033	21	48.84	3.719	0.827	1.056	1.616	0.945
9-10	ALL USER	0.081	12	11.21	5.475	1.512	1.314	1.703	1.272
	EMPOF	0.177	8	12.70	5.475	1.571	1.376	1.800	1.325
	RECEP	0.081	4	9.09	5.430	1.428	1.229	1.570	1.198
10-11	ALL USER	0.527	0	0.0	5.419	2.594	1.071	2.594	1.071
	EMPOF	0.527	0	0.0	4.772	2.575	0.999	2.575	0.999
	RECEP	0.570	0	0.0	5.419	2.621	1.178	2.621	1.178
11-12	ALL USER	0.130	1	0.91	5.095	2.701	1.284	2.726	1.263
	EMPOF	0.130	1	1.56	4.882	2.719	1.252	2.762	1.213
	RECEP	0.142	0	0.0	5.095	2.675	1.339	2.675	1.339
12- 1	ALL USER	0.118	3	2.88	4.245	2.247	1.122	2.314	1.068
	EMPOF	0.118	3	4.84	4.080	2.217	1.070	2.330	0.968
	RECEP	0.119	0	0.0	4.245	2.291	1.207	2.291	1.207
1- 2	ALL USER	0.112	1	0.95	4.822	2.288	1.199	2.310	1.183
	EMPOF	0.112	0	0.0	4.822	2.201	1.165	2.201	1.165
	RECEP	0.346	1	2.38	4.612	2.419	1.251	2.478	1.206
2- 3	ALL USER	0.230	0	0.0	5.355	2.792	1.045	2.792	1.045
	EMPOF	0.230	0	0.0	5.355	2.817	1.080	2.817	1.080
	RECEP	1.043	0	0.0	4.996	2.755	1.003	2.755	1.003
3- 4	ALL USER	0.122	5	6.33	5.732	2.502	1.609	2.671	1.520
	EMPOF	0.122	3	5.08	5.732	2.480	1.655	2.613	1.592
	RECEP	0.660	2	10.00	5.066	2.566	1.507	2.851	1.295
4- 5	ALL USER	0.100	15	18.75	4.235	1.214	0.934	1.494	0.807
	EMPOF	0.100	13	19.40	4.235	1.216	0.949	1.509	0.820
	RECEP	0.262	2	15.38	2.527	1.203	0.883	1.421	0.770
8-5	ALL USER	0.033	73	8.00	5.732	2.129	1.342	2.314	1.237
8-5	EMPOF	0.100	43	7.57	5.732	2.117	1.331	2.290	1.233
8-5	RECEP	0.033	30	8.70	5.430	2.149	1.362	2.353	1.245

MEAN* AND STD DEV* ARE FOR NON-ZERO TIMES ONLY

----- TOTAL QUEUE WAITING TIME -----		
USER	HOURS	% OF AVAILABLE TIME
ALL USER	32.397	19.998
EMPOF	18.524	13.722
RECEP	12.025	44.536

Job Order Queue Report

The Job Order Queue Report is divided into a queue contents portion and a queue waiting times portion. The types of information given are the same as given in the Interview Queue Report, but the subject is the number of job orders awaiting handling and the length of time they must wait. This report is displayed in Table 9.

TABLE 9. JOB ORDER QUEUE REPORT

= JOB ORDER QUEUE =

	[A]		[B]	[C]	[D]	[E]
	----- QUEUE CONTENTS -----					
TIME	ENTRIES	ENTRIES*	MIN	MAX	AVERAGE	NOW
8- 9	6	6	0	1	0.056	0
9-10	7	7	0	1	0.050	0
10-11	8	8	0	1	0.070	0
11-12	5	5	0	1	0.050	0
12- 1	6	6	0	1	0.049	0
1- 2	6	6	0	2	0.031	0
2- 3	5	5	0	2	0.075	1
3- 4	5	5	0	1	0.070	0
4- 5	10	10	0	2	0.093	1
8-5	58	58	0	2	0.060	

ENTRIES* INCLUDES ONLY NON-ZERO QUEUE TIMES

	[F]	[G]	[H]	[I]	[J]	[K]	[L]	[M]
	----- QUEUE WAITING TIMES ---							
TIME	MIN	ZERO-#	ZERO-%	MAX	MEAN	STD DEV	MEAN*	STD DEV*
8- 9	0.064	0	0.0	1.035	0.559	0.388	0.559	0.388
9-10	0.003	0	0.0	1.659	0.428	0.595	0.428	0.595
10-11	0.175	0	0.0	0.950	0.521	0.318	0.521	0.318
11-12	0.258	0	0.0	1.236	0.605	0.394	0.605	0.394
12- 1	0.082	0	0.0	0.979	0.495	0.374	0.495	0.374
1- 2	0.152	0	0.0	0.578	0.314	0.163	0.314	0.163
2- 3	0.128	0	0.0	1.312	0.740	0.564	0.740	0.564
3- 4	0.013	0	0.0	2.080	0.991	0.788	0.991	0.788
4- 5	0.029	0	0.0	1.546	0.523	0.479	0.523	0.479
8-5	0.003	0	0.0	2.080	0.557	0.468	0.557	0.468

MEAN* AND STD DEV* ARE FOR NON-ZERO TIMES ONLY

CHAPTER FOUR

USE OF THE SIMULATION

The activity level in a local office is affected by many external variables. A major layoff at a local factory, for example, would increase the number of people needing services. Changes in the type or extent of services provided, such as the introduction of a special program for veterans, could also affect the activity level. Changes in the number of people served by the local office or in the types of services provided can present resource allocation problems. A simulation is an inexpensive way to answer some of the questions that commonly arise in a changing situation.

This simulation is primarily a planning tool designed to deal with a variety of Employment Service problems. The simulation can help the manager to choose between alternative solutions and answer specific questions stemming from new situations. For example,

1) What is the best way to cope with a budget cut while serving the greatest number of applicants per day?
   a) Cut one terminal, one receptionist, and one interviewer?
   b) Cut just one terminal and one receptionist?
2) What is the best way to handle a sudden increase in the number of people to be served? Hire more receptionists?
   a) How many part-time temporary receptionists are needed?
   b) What hours should they work?

The simulation can also be used to maximize the allocation of existing resources and to help lay a foundation for budget requests. For example, it might show how an extra terminal would reduce staff waiting time.

Although the simulation is primarily a planning tool, it can provide valuable input to the policy development process, particularly in the area of budget estimates. Consider the following hypothetical situation. Management is concerned that applicants have to wait too long to see interviewers and that too many applicants leave

at the end of the day without being interviewed or give up and leave after some substantial period of time, A policy decision to set a 20 percent increase in the number of applicants served each day as a target is under consideration. The decision maker must answer two immediate questions. How massive would changes in current operations have to be to effect such a change? What would the changes cost in qualitative aspects of service such as the length of interviews and the time an interviewer can spend doing terminal-aided job searches?

The simulation allows the decision maker to determine the degree to which changes in staff levels and distributions and numbers of terminals will increase the number of applicants served -- and the effect the increase will have on the quality of services. Simulation allows the expense and effect of a policy change to be evaluated before the change is actually implemented.

The following hypothetical management situation will be used to demonstrate the use of the simulation.

A local office manager has a staff of 20 employment officers, one full-time receptionist, and four part-time receptionists. At any given time, 15 of the 20 employment officers are assigned to the tasks of interviewing applicants and taking job orders, while the other five perform essential but unrelated tasks. All 20 are capable of doing either job. The part-time receptionists are scheduled so that two of them are working at all times, which means that a total of three receptionists are working at any given time during the day. The entire staff shares two terminals.

To be realistic, we assume the local office budget is fully committed. Only relatively small amounts of uncommitted money remain, certainly not enough to add additional full-time staff. Nonetheless, the manager has problems. The office starts falling behind by midmorning, and it never catches up. The line in front of the receptionists' desks stretches out the front door. Three to four times as many people are waiting to be interviewed as there are chairs for them to sit on. The waits are not short, and some applicants are in the office for over two hours. As the staff falls further behind, the office becomes jammed with people, making

both the staff and the applicants irritable. Although the front doors are locked at 4:30 p.m., applicants are still waiting to be interviewed at 5 p.m.

The manager hopes that rearranging the hours the staff spends on various tasks will increase the number of applicants served and reduce congestion. In particular, he would like to try using more than 15 employment officers to interview applicants during busy hours and using more than five on non-interviewing tasks during slack periods.

The manager would like to see the office system behave as follows: there should never be more than 80 applicants in the system at any given time, and the hourly averages should be less than 60; there should never be more than 15 people waiting to see a receptionist nor more than 20 waiting to be interviewed.

If the manager attempts to experiment with alternative allocations of his staff, the system behavior may become even worse, a possibility he finds repugnant. He chooses simulation as a non-threatening alternative to direct experimentation. First, he determines the values of the simulation input parameters (discussed in Chapter 3) that describe his office configuration. Then, he runs the simulation for the first time and verifies that the simulation adequately represents the behavior of his office. The output for this run was shown in the previous section.

Next, the manager attempts to determine from the simulation output where his bottlenecks are occurring and what can be done about them. (See Table 10.) From the Applicant Report, he can see that the largest number of arrivals occurs in midmorning (140 from 10-11) [A] and that the number of people in the system is very high after 11 a.m., as he surmised from watching his own office. In the Receptionist Facility Report [B], he notices that the receptionists are spending a high percentage of the busiest periods waiting to use a terminal. The Terminal Queue Report [D] verifies that observation and shows that receptionists are spending 44 percent of their day waiting for a terminal. Obviously, the office needs another terminal.

Assuming a reduction in terminal working time, the utilization

figures in the Receptionist Facility Report [B] show too many receptionists from 8-10 and from 3-5. For example, the utilization rate from 4-5 is only 17.2 percent.

The utilization statistics in the Employment Officer Facility Report [C] show an excess of employment officers in the first hour of the day; but with that exception, nothing else can be evaluated accurately until the effect of the additional terminal can be determined. The complete, modified input parameters and simulation output for the second run appear in Table 11.

As is apparent from the Applicant Report of the second simulation run, system performance was greatly enhanced by the addition of the terminal. In particular, the maximum length of time any applicant spent in the system dropped by approximately one hour. The average number of people in the system is over 60 from 11-12 only [A].

The receptionist-utilization statistics indicate that there are too many receptionists after 10 a.m., but the Receptionist Queue Report shows that the constraint of no more than 15 people waiting for a receptionist is violated from 10-11. The manager decides to add one more receptionist from 10-11 and reduce the number of receptionists after 11 a.m. [B].

The Employment Officer Facility Report and the Interview Queue Report show the manager that the employment officers cannot keep up with the load from 10-3 but that the number of officers can be drastically reduced during the last hour of the day [C]. He decides to add employment officers in the late morning and early afternoon and drop back to nine for the last hour. The simulation output for this new configuration appears in Table 12.

Again, system behavior improves, but it still does not satisfy the manager's constraints. The average number of people in the system from 11-12 is still slightly high [A]. Although reduction in the number of receptionists after 11 a.m. did not cause unacceptable behavior, the addition of the fourth receptionist did not reduce the maximum number of applicants in the receptionists' queue [B] from 10-11 to an acceptable level.

TABLE 10. FIRST SIMULATION CYCLE

OUTPUT SUMMARY

[A]			[B]			[C]		
			RECEPTIONIST			EMPLOYMENT OFFICER		
TIME	CLASS	AR-RIVALS	LEVEL	ACTIVITY	UTILIZA-TION	LEVEL	ACTIVITY	UTILIZA-TION
8-9	ALL	97	3	RECEPTION	0.503	15	INTERVIEW	0.713
	NEW	37		ENCOUNTER	0.191		DISCUSSION	0.560
	OLD	43		TERM WAIT	0.197		TERM WAIT	0.071
	OTH	17		COMPUTER	0.115		COMPUTER	0.083
				MISC.	0.497		JOB ORDER	0.014
				HR. SUB-TOTAL	1.000		MISC.	0.273
							HR. SUB-TOTAL	1.000
9-10	ALL	86	3	RECEPTIONIST	0.768	15	INTERVIEW	0.879
	NEW	24		ENCOUNTER	0.241		DISCUSSION	0.675
	OLD	47		TERM WAIT	0.410		TERM WAIT	0.101
	OTH	15		COMPUTER	0.117		COMPUTER	0.102
				MISC.	0.232		JOB ORDER	0.014
				HR. SUB-TOTAL	1.000		MISC.	0.107
							HR. SUB-TOTAL	1.000
10-11	ALL	140	3	RECEPTIONIST	1.000	15	INTERVIEW	0.977
	NEW	58		ENCOUNTER	0.206		DISCUSSION	0.668
	OLD	59		TERM WAIT	0.660		TERM WAIT	0.202
	OTH	23		COMPUTER	0.134		COMPUTER	0.107
				MISC.	0.000		JOB ORDER	0.013
				HR. SUB-TOTAL	1.000		MISC.	0.010
							HR. SUB-TOTAL	1.000
11-12	ALL	90	3	RECEPTION	1.000	15	INTERVIEW	0.986
	NEW	31		ENCOUNTER	0.201		DISCUSSION	0.680
	OLD	44		TERM WAIT	0.684		TERM WAIT	0.196
	OTH	15		COMPUTER	0.115		COMPUTER	0.110
				MISC.	0.000		JOB ORDER	0.014
				HR. SUB-TOTAL	1.000		MISC.	0.000
							HR. SUB-TOTAL	1.000
12-1	ALL	62	3	RECEPTION	0.840	15	INTERVIEW	0.986
	NEW	21		ENCOUNTER	0.187		DISCUSSION	0.724
	OLD	33		TERM WAIT	0.532		TERM WAIT	0.154
	OTH	8		COMPUTER	0.121		COMPUTER	0.108
				MISC.	0.160		JOB ORDER	0.014
				HR. SUB-TOTAL	1.000		MISC.	0.000
							HR. SUB-TOTAL	1.000

TABLE 10. FIRST SIMULATION CYCLE

OUTPUT CYCLE (Cont.)

[A]			[B]			[C]		
			RECEPTIONIST			EMPLOYMENT OFFICER		
TIME	CLASS	AR-RIVALS	LEVEL	ACTIVITY	UTILIZA-TION	LEVEL	ACTIVITY	UTILIZA-TION
1-2	ALL	99	3	RECEPTION	0.850	15	INTERVIEW	0.988
	NEW	35		ENCOUNTER	0.159		DISCUSSION	0.727
	OLD	55		TERM WAIT	0.574		TERM WAIT	0.151
	OTH	9		COMPUTER	0.117		COMPUTER	0.110
				MISC.	0.150		JOB ORDER	0.012
				HR. SUB-TOTAL	1.000		MISC.	0.000
							HR. SUB-TOTAL	1.000
2-3	ALL	63	3	RECEPTION	1.000	15	INTERVIEW	0.987
	NEW	17		ENCOUNTER	0.170		DISCUSSION	0.670
	OLD	36		TERM WAIT	0.694		TERM WAIT	0.211
	OTH	10		COMPUTER	0.136		COMPUTER	0.106
				MISC.	0.000		JOB ORDER	0.013
				HR. SUB-TOTAL	1.000		MISC.	0.000
							HR. SUB-TOTAL	1.000
3-4	ALL	63	3	RECEPTION	0.502	15	INTERVIEW	0.986
	NEW	38		ENCOUNTER	0.167		DISCUSSION	0.719
	OLD	15		TERM WAIT	0.279		TERM WAIT	0.159
	OTH	10		COMPUTER	0.056		COMPUTER	0.108
				MISC.	0.498		JOB ORDER	0.014
				HR. SUB-TOTAL	1.000		MISC.	0.000
							HR. SUB-TOTAL	1.000
4-5	ALL	26	3	RECEPTION	0.172	15	INTERVIEW	0.987
	NEW	8		ENCOUNTER	0.045		DISCUSSION	0.777
	OLD	13		TERM WAIT	0.087		TERM WAIT	0.091
	OTH	5		COMPUTER	0.040		COMPUTER	0.119
				MISC.	0.828		JOB ORDER	0.013
				HR. SUB-TOTAL	1.000		MISC.	0.000
							HR. SUB-TOTAL	1.000
8-5	ALL	726		RECEPTION	0.737		INTERVIEW	0.943
8-5	NEW	269		ENCOUNTER	0.174		DISCUSSION	0.689
8-5	OLD	345		TERM WAIT	0.458		TERM WAIT	0.148
8-5	OTH	112		COMPUTER	0.106		COMPUTER	0.106
8-5				MISC.	0.263		JOB ORDER	0.013
							MISC.	0.043

-------TERMINAL QUEUE WAITING TIME-------

USER	HOURS	% OF AVAILABLE TIME
ALL USERS	32.397	19.998
EMPOF	18.524	13.722
RECEP	12.025	44.536

TABLE 11. SECOND SIMULATION CYCLE

OUTPUT SUMMARY

		[A] APPLICANTS IN SYSTEM				[B] RECEPTIONIST				[C] EMPLOYMENT OFFICER				
		PEOPLE		TIME										
TIME	CLASS	RUN 1 AVERAGE	RUN 2 AVERAGE	RUN 1 MAX	RUN 2 MAX	LEVEL	ACTIVITY	UTILIZ-ATION	QUEUE MAX	LEVEL	ACTIVITY	UTILIZ-ATION	QUEUE MAX	NOW
8-9	ALL	29.936	29.459	43.608	43.494	2	RECEPTION	0.519	7	13	INTERVIEW	0.773	6	0
	NEW	14.345	14.685	41.892	41.168		ENCOUNTER	0.291			DISCUSSION	0.652		
	OLD	11.159	10.343	43.608	43.494		TERM WAIT	0.051			TERM WAIT	0.018		
	OTH	4.432	4.432	26.071	26.071		COMPUTER	0.177			COMPUTER	0.102		
							MISC.	0.481			JOB ORDER	0.016		
							HR. SUB-TOTAL	1.000			MISC.	0.211		
											HR. SUB-TOTAL	1.000		
9-10	ALL	36.705	33.578	48.177	42.221	2	RECEPTION	0.643	11	15	INTERVIEW	0.842	9	8
	NEW	17.572	16.335	44.787	42.221		ENCOUNTER	0.364			DISCUSSION	0.727		
	OLD	14.828	12.937	48.177	37.190		TERM WAIT	0.090			TERM WAIT	0.007		
	OTH	4.306	4.306	26.422	26.442		COMPUTER	0.189			COMPUTER	0.108		
							MISC.	0.357			JOB ORDER	0.014		
							HR. SUB-TOTAL	1.000			MISC.	0.145		
											HR. SUB-TOTAL	1.000		
10-11	ALL	62.939	48.926	60.090	47.503	3	RECEPTION	0.513	22	15	INTERVIEW	0.947	19	19
	NEW	32.016	26.178	56.295	42.689		ENCOUNTER	0.237			DISCUSSION	0.784		
	OLD	23.534	15.358	60.090	47.503		TERM WAIT	0.130			TERM WAIT	0.037		
	OTH	7.390	7.390	24.855	24.855		COMPUTER	0.147			COMPUTER	0.126		
							MISC.	0.487			JOB ORDER	0.013		
							HR. SUB-TOTAL	1.000			MISC.	0.040		
											HR. SUB-TOTAL	1.000		
11-12	ALL	96.868	72.665	84.972	65.259	3	RECEPTION	0.464	12	15	INTERVIEW	0.986	43	42
	NEW	52.660	38.391	84.269	65.174		ENCOUNTER	0.235			DISCUSSION	0.830		
	OLD	39.738	29.803	84.972	65.259		TERM WAIT	0.102			TERM WAIT	0.031		
	OTH	4.471	4.471	26.075	26.075		COMPUTER	0.127			COMPUTER	0.124		
							MISC.	0.536			JOB ORDER	0.014		
							HR. SUB-TOTAL	1.000			MISC.	0.000		
											HR. SUB-TOTAL	1.000		

TABLE 11. SECOND SIMULATION CYCLE

OUTPUT SUMMARY (Cont.)

	[A] APPLICANTS IN SYSTEM				[B] RECEPTIONIST				[C] EMPLOYMENT OFFICER				
	PEOPLE		TIME										
TIME CLASS	RUN 1 AVERAGE	RUN 2 AVERAGE	RUN 1 MAX	RUN 2 MAX	LEVEL	ACTIVITY	UTILIZ-ATION	QUEUE MAX	LEVEL	ACTIVITY	UTILIZ-ATION	QUEUE MAX	NOW
12-1 ALL	91.945	59.474	114.102	80.481	3	RECEPTION	0.251	4	15	INTERVIEW	0.987	42	28
NEW	46.464	28.666	103.480	72.088		ENCOUNTER	0.117			DISCUSSION	0.837		
OLD	43.235	28.561	114.102	80.481		TERM WAIT	0.048			TERM WAIT	0.019		
OTH	2.247	2.247	25.682	25.682		COMPUTER	0.087			COMPUTER	0.130		
						MISC.	0.749			JOB ORDER	0.013		
						HR. SUB-TOTAL	1.000			MISC.	0.000		
										HR. SUB-TOTAL	1.000		
1-2 ALL	100.056	55.074	117.874	70.493	3	RECEPTION	0.527	7	15	INTERVIEW	0.988	28	25
NEW	42.943	23.088	114.335	66.203		ENCOUNTER	0.221			DISCUSSION	0.821		
OLD	53.900	28.772	117.874	70.493		TERM WAIT	0.146			TERM WAIT	0.032		
OTH	3.214	3.214	24.038	24.038		COMPUTER	0.161			COMPUTER	0.135		
						MISC.	0.473			JOB ORDER	0.012		
						HR. SUB-TOTAL	1.000			MISC.	0.000		
										HR. SUB-TOTAL	1.000		
2-3 ALL	112.725	54.614	113.000	77.528	3	RECEPTION	0.384	4	15	INTERVIEW	0.987	33	18
NEW	44.151	22.892	107.795	64.403		ENCOUNTER	0.141			DISCUSSION	0.823		
OLD	65.495	28.641	113.000	77.528		TERM WAIT	0.140			TERM WAIT	0.043		
OTH	3.081	3.081	24.468	24.468		COMPUTER	0.103			COMPUTER	0.121		
						MISC.	0.616			JOB ORDER	0.013		
						HR. SUB-TOTAL	1.000			MISC.	0.000		
										HR. SUB-TOTAL	1.000		

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TABLE 11. SECOND SIMULATION CYCLE

OUTPUT SUMMARY (Cont.)

[A] APPLICANTS IN SYSTEM						[B] RECEPTIONIST				[C] EMPLOYMENT OFFICER				
		PEOPLE		TIME										
TIME	CLASS	RUN 1 AVERAGE	RUN 2 AVERAGE	RUN 1 MAX	RUN 2 MAX	LEVEL	ACTIVITY	UTILIZ-ATION	QUEUE MAX	LEVEL	ACTIVITY	UTILIZ-ATION	QUEUE MAX	NOW
3-4	ALL	102.387	39.460	133.710	63.724	2	RECEPTION	0.274	4	15	INTERVIEW	0.950	18	0
	NEW	49.832	23.126	124.907	63.724		ENCOUNTER	0.201			DISCUDDION	0.812		
	OLD	48.857	12.623	133.710	63.303		TERM WAIT	0.009			TERM WAIT	0.015		
	OTH	3.710	3.710	25.626	25.626		COMPUTER	0.064			COMPUTER	0.123		
							MISC.	0.726			JOB ORDER	0.014		
							HR. SUB-TOTAL	1.000			MISC.	0.037		
											HR. SUB-TOTAL	1.000		
4-5	ALL	72.770	13.025	139.954	44.149	2	RECEPTION	0.129	1	15	INTERVIEW	0.458	3	0
	NEW	47.110	8.471	139.954	44.149		ENCOUNTER	0.068			DISCUSSION	0.390		
	OLD	24.258	3.153	129.036	38.879		TERM WAIT	0.000			TERM WAIT	0.002		
	OTH	1.402	1.402	26.167	26.167		COMPUTER	0.060			COMPUTER	0.066		
							MISC.	0.871			JOB ORDER	0.013		
							HR. SUB-TOTAL	1.000			MISC.	0.528		
											HR. SUB-TOTAL	1.000		
8-5	ALL	78.482	45.142	139.954	80.481		RECEPTION	0.412	22		INTERVIEW	0.880	43	-
8-5	NEW	38.566	22.426	139.954	72.088		ENCOUNTER	0.208			DISCUSSION	0.742		
8-5	OLD	36.111	18.910	133.710	80.481		TERM WAIT	0.089			TERM WAIT	0.023		
8-5	OTH	3.806	3.806	26.422	26.422		COMPUTER	0.124			COMPUTER	0.115		
8-5							MISC.	0.588			JOB ORDER	0.014		
											MISC.	0.107		

TABLE 12. THIRD SIMULATION CYCLE

OUTPUT SUMMARY

	[A]	[B]	[C]	[D]	[E]	[F]	[G]	[H]
TIME	APPLICANTS		INTERVIEW QUEUE CONTENTS					
	CLASS	AIS*	RQ**	RUN 2			RUN 3		
				MAX	AVERAGE	NOW***	MAX	AVERAGE	NOW***
8-9	ALL	29.459	7	6	1.191	0	6	1.191	0
	NEW	14.685							
	OLD	10.343							
	OTH	4.432							
9-10	ALL	33.578	11	9	1.705	8	9	1.705	8
	NEW	16.335							
	OLD	12.937							
	OTH	4.306							
10-11	ALL	48.101	17	19	4.380	19	19	3.557	19
	NEW	25.490							
	OLD	15.222							
	OTH	7.390							
11-12	ALL	64.617	13	43	34.333	42	28	21.847	22
	NEW	33.409							
	OLD	26.736							
	OTH	4.471							
12-1	ALL	44.197	8	42	33.094	28	26	16.283	9
	NEW	21.736							
	OLD	20.214							
	OTH	2.247							
1-2	ALL	36.957	5	28	20.139	25	13	2.349	11
	NEW	17.462							
	OLD	16.281							
	OTH	3.214							
2-3	ALL	39.271	4	33	27.117	18	20	11.292	0
	NEW	16.447							
	OLD	19.743							
	OTH	3.081							
3-4	ALL	27.742	7	18	8.122	0	2	0.170	2
	NEW	18.909							
	OLD	5.122							
	OTH	3.710							

TABLE 12. THIRD SIMULATION CYCLE

OUTPUT SUMMARY (Cont.)

	[A]	[B]	[C]	[D]	[E]	[F]	[G]	[H]
	APPLICANTS		INTERVIEW QUEUE CONTENTS					
			RUN 2			RUN 3		
TIME	CLASS	AIS*	RQ**	MAX	AVERAGE	NOW***	MAX	AVERAGE	NOW***
4-5	ALL	14.611	2	3	0.076	0	5	1.279	0
	NEW	9.209							
	OLD	4.000							
	OTH	1.402							
8-5	ALL	37.615	17	43	14.467		28	6.630	
8-5	NEW	19.298							
8-5	OLD	14.511							
8-5	OTH	3.806							

-------TERMINAL QUEUE WAITING TIME-------

USER	HOURS	% OF AVAILABLE TIME
ALL USERS	4.813	3.209
EMPOF	1.386	1.042
RECEP	1.630	9.585

*AIS - Average number of applicants in the system

**RQ - Maximum number of applicants in the receptionists queue

The Interview Queue Report shows substantial improvement in the number of people waiting to be interviewed [C-E], but more employment officers are needed from 10-12 and 1-3. Fewer are needed from 3-4.

The Terminal Queue Report [I,J] shows that receptionists spend nearly 10 percent of their time waiting for a terminal, apparently because as more staff members are used, competition for terminals increases. Assuming that this problem will be compounded when more staff are added in the next simulation, and hoping to reduce the number of applicants waiting for the receptionists, the manager decides to add another terminal.

He changes input again and simulates a new configuration. The output from this simulation appears in Table 13.

The addition of a fourth terminal substantially reduces the number of people waiting for the receptionists. Comparing the Receptionist Queue Reports from Table 13, we see a 35 percent reduction in the average queue content [B,D]. In the troublesome period from 10-11, the maximum queue content [A,C] dropped from 17 to three. In fact, in the Receptionist Facility Report, the manager discovers that he doesn't need four receptionists from 10-11, after all.

At this point, the manager sees that all of his original constraints have been met except for the maximum length of the interview queue [G].

The Interview Queue Report shows that the 10-11 period barely meets the constraint, and the 11-12 period violates it. The manager wants to reduce the number of people waiting from 11-12, but he is already using all 20 employment officers in that hour. He notices that the Interview Queue Report shows 16 people waiting [H] at 11 a.m. and decides to use all 20 employment officers from 10-11 to reduce waiting-line spillover into the 11-12 period. He also decides to reduce the number of employment officers in the 3-5 period because of the small queue size during that period.

Simulating another day (Run 5), he finds that all of his constraints are now met. Run 5 can be found in Appendix A. Other runs are available

TABLE 13. FOURTH SIMULATION CYCLE

OUTPUT SUMMARY

	[A]	[B]	[C]	[D]	[E]		[F]	[G]	[H]
	RECEPTIONIST							INTERVIEW	
	QUEUE CONTENTS							QUEUE CONTENTS	
	RUN 3		RUN 4						
TIME	MAX	AVERAGE	MAX	AVERAGE	LEVEL	ACTIVITY	UTILIZ-ATION	MAX	NOW
8-9	7	0.563	7	0.417	2	RECEPTION	0.480	5	0
						ENCOUNTER	0.291		
						TERM WAIT	0.012		
						COMPUTER	0.177		
						MISC.	0.520		
						HR. SUB-TOTAL	1.000		
9-10	11	0.848	4	0.298	2	RECEPTION	0.562	9	6
						ENCOUNTER	0.364		
						TERM WAIT	0.010		
						COMPUTER	0.189		
						MISC.	0.438		
						HR. SUB-TOTAL	1.000		
10-11	17	1.153	3	0.037	4	RECEPTION	0.327	20	16
						ENCOUNTER	0.191		
						TERM WAIT	0.021		
						COMPUTER	0.116		
						MISC.	0.673		
						HR. SUB-TOTAL	1.000		
11-12	13	2.111	7	0.735	2	RECEPTION	0.577	21	7
						ENCOUNTER	0.327		
						TERM WAIT	0.072		
						COMPUTER	0.178		
						MISC.	0.423		
						HR. SUB-TOTAL	1.000		
12-1	8	1.665	7	0.870	1	RECEPTION	0.647	11	0
						ENCOUNTER	0.351		
						TERM WAIT	0.030		
						COMPUTER	0.266		
						MISC.	0.353		
						HR. SUB-TOTAL	1.000		

TABLE 13. FOURTH SIMULATION CYCLE

OUTPUT SUMMARY (Cont.)

	[A]	[B]	[C]	[D]	[E]	[F]		[G]	[H]
	RECEPTIONIST							QUEUE	
	QUEUE CONTENTS								
	RUN 3		RUN 4					QUEUE CONTENTS	
TIME	MAX	AVERAGE	MAX	AVERAGE	LEVEL	ACTIVITY	UTILIZ-ATION	MAX	NOW
1-2	5	0.706	6	0.588	2	RECEPTION	0.589	12	11
						ENCOUNTER	0.331		
						TERM WAIT	0.019		
						COMPUTER	0.238		
						MISC.	0.411		
						HR. SUB-TOTAL	1.000		
2-3	4	0.211	5	1.537	1	RECEPTION	0.788	15	0
						ENCOUNTER	0.422		
						TERM WAIT	0.056		
						COMPUTER	0.309		
						MISC.	0.212		
						HR. SUB-TOTAL	1.000		
3-4	7	0.569	7	0.536	1	RECEPTION	0.527	2	1
						ENCOUNTER	0.399		
						TERM WAIT	0.000		
						COMPUTER	0.128		
						MISC.	0.473		
						HR. SUB-TOTAL	1.000		
4-5	2	0.107	2	0.085	1	RECEPTION	0.284	5	0
						ENCOUNTER	0.139		
						TERM WAIT	0.023		
						COMPUTER	0.121		
						MISC.	0.716		
						HR. SUB-TOTAL	1.000		
8-5	17	0.881	7	0.568		RECEPTION	0.531	21	-
8-5						ENCOUNTER	0.313		
8-5						TERM WAIT	0.027		
8-5						COMPUTER	0.191		
8-5						MISC.	0.469		

from ILIR. Comparing the man-days used for receptionists, Receptionist Facility Report, and employment officers in the Employment Officer Facility Report, in his first and last simulations, he finds that his final run uses two more hours of employment officer time and 12 fewer hours of receptionist time (Table 14). Two more terminals are required; but the solution, as a whole, can be financed through his present budget.

The manager in this hypothetical situation might wish to further refine his solution, particularly by reducing the number of employment officers in the 3-5 period; but further runs are not necessary to demonstrate the use of simulation. The example demonstrates the iterative approach required by simulation: successive solutions are tried until the best solution is settled upon.

In the example, our hypothetical manager shifted his resources to meet demand. This commonsense approach is generally effective, but determining which resources to use and in what quantities can be a problem. Even in relatively simple systems such as the local office simulated here, interactions in the system can cause complex and, frequently, counter-intuitive behavior. Doubts about which of two resource allocations will be most effective can be resolved by simulating both.

TABLE 14. COMPARISONS, FIRST AND LAST RUNS

Statistics were taken from facility reports for the receptionists and employment officers for the first and fifth (last) simulation runs.

Run	1	5	5 - 1	
Recep	3.37	1.87	-1.50	receptionist-days
Empof	16.87	17.12	.25	employment officer - days

-1.50 r-days
x 8 hrs./day

-12 hours of receptionist time saved per day

.25 emp-days
x 8 hrs./day

2 more hours of employment officer time used

CHAPTER FIVE

SALT LAKE CITY PLACEMENT CENTER TIME STUDY

Introduction

The models discussed in previous chapters were derived from visits to numerous Employment Service local offices in New York, Denver, Boulder, Milwaukee, Detroit, and Salt Lake City. Much of the data used in this model came from a 3 week time study at the Placement Center of the Salt Lake City (SLC) local office. Major discrepancies between the SLC Placement Center and the simulations underlying the descriptive model are noted below. Table 16 summarizes some of the data collected.

Model Abstractions

The descriptive model abstracted from the SLC local office was simplified to make the model workable and to simplify the prototype simulation so that the underlying concepts could be presented clearly. For these reasons, the following aspects of the SLC office are not represented exactly as they appear in the office.

Interviewer Clustering

In the SLC office, interviewers were grouped in clusters, each of which dealt with a certain type of applicant only. For example, one cluster handled only clerical placements. In the prototype simulation, any applicant could be serviced by any interviewer.

Terminal Applications

Terminals in the SLC Placement Center were used for many functions, but they had two primary functions. First, the receptionist checked the registration of applicants, as described in the descriptive model. Second, interviewers primarily used terminals to match

applicants to job orders. In the model, interviewers used terminals to match jobs to applicants as part of the interviewing process.

Centralized Mode

Two of the six terminals at the Placement Center operated in centralized mode, that is, clerks performed retrievals at the request of interviewers and administrators. This operation is omitted from the model. In the model, all receptionists and interviewers use the same pool of terminals.

Down Time

The simulation does not model periods when either terminals or computer systems are malfunctioning or not operating. Unfortunately, such periods do exist in the real world.

Other Activities

Activities other than interviewing and job order taking are all lumped together under the heading of miscellaneous activities.

Length of Interview

There are many factors that might potentially affect the length of interview. Leaving an important factor out of the simulation might cause misleading results.

During the modeling of the interview process, the modelers hypothesized that three factors might affect the length of an interview:

1) The type of job the applicant desires.
2) Whether or not the applicant has been to the Employment Service before.
3) The characteristics of the interviewer (i.e., would some interviewers be predisposed to spend either more or less time with the applicant).

None of these factors were accounted for in the simulation except 2) whether the applicant had been to the Employment Service before.

To test the importance of these factors, data from the time study was used to evaluate three single factor analysis-of-variance models. The analysis-of-variance results appear in Table 15. None of the three tests were significant at an α-level (the probability of rejecting a true hypothesis) of .05. These results provide further support for using our simulation model. Factor 2) which is in our simulation was significant at the .06 level.

Collection of Data

Data was collected at various stations to trace the flow of applicants through the SLC office. As each applicant reached each station, the time was recorded on his card. Time was expressed in hours and hundredths of hours. Time intervals between stations were calculated later. A description of the information gathered at each station follows.

1) Entrance: At the front door, every fifth applicant was given a card stamped with the current time. If the applicant followed the standard procedure, he proceeded to the receptionist's desk. It was not uncommon, however, for applicants familiar with the office to go to the job display area first and then to the reception desk or to the exit.

2) Reception desk: The receptionist determined whether or not the applicant had previously come to the Employment Service and what the applicant was applying for:

a) Unemployment Insurance
b) Foodstamps
c) Welfare
d) CETA/PEP

When an applicant returned to the desk from the job display boards or from an interview, only the time was recorded.

3) Interviewer: The interviewer stamped the time on the applicant's card both at the beginning and at the end of the interview. The interviewer recorded three other items of information:

TABLE 15. ANALYSIS OF VARIANCE
RESULTS FOR LENGTH OF INTERVIEW

The results of the three analysis-of-variance models are summarized in the single table below.

Source	DF	Sum of Squares	Mean Square	F-statistic	Significance
Interviewer	45	73.475	1.6328	1.3105	.0860
Occupation (DOT)	9	14.085	1.5650	1.2400	.2666
New/old	1	4.3278	4.3278	3.4301	.0643
Total	907	1147.4			

a) The applicant's DOT (Dictionary of Occupational Titles) code.

b) His own employee number.

c) Whether or not the applicant had been to the job display area prior to the interview.

After the interview, the applicant either left the office or returned to the reception desk to await another interview.

4) Exit: The time of the applicant's departure was recorded on his way out of the office.

Much of the information gathered in the time study has already been discussed in the presentation of the models. The significant remaining information is summarized in Table 16.

Although not a part of our time study, we obtained statistics collected by the Utah Department of Employment during the second week of the time study. There were only 41 job searches performed on the terminal or about 8 per day. There were ten times as many applicant searches performed during the same period. Not every job search results in a referral and not every referral results in a placement. Therefore the number of placements resulting from job searches was low in Utah as well as in Colorado.

Of the total of 2770 applicants that came into the Utah employment study during the second week of the time study less than 2% received computer job searches. This is primarily because most applicants find jobs from boards which list jobs by occupational category. Perhaps in a large office such as New York City or Los Angeles boards would not be feasible and a computer search would be used more often.

TABLE 16. SOME TIME STUDY CHARACTERISTICS

Characteristics of Arriving Applicants at Reception Desk	NO	YES
New applicant (not registered)	1244	397
Unemployment Insurance	1437	204
Foodstamps	1633	8
Welfare	1637	4
CETA/PEP	1613	28
Went to job display area before 1st interview	270	1371

Applicant Time Distribution	Average Value in Hours
Entrance to reception desk	.0846
Return to reception desk	.3553
Reception desk to interviewer	.2611
Interview length	.1916
Total interruptions during interview	.0497
Interview to exit	.1307
Second interview	.1391
Third interview	.0766

Occupation Desired by Applicant	Count
1st digit of first DOT on Application	
0	56
1	55
2	315
3	84
4	6
5	9
6	57
7	41
8	227
9	176
blank	615

CHAPTER SIX

RECOMMENDATIONS AND CONCLUSIONS

The prototype simulation shows that simulation can be an effective tool for the local office manager. It can be used to evaluate the effect of any change in the local office.

Two different approaches could be developed to expand the use of simulation in the Employment Service.

1) Separate simulations of several types of local offices, each having fairly flexible input parameters through which the local office manager could describe his own system environment.
2) One simulation with the flexibility to redefine the underlying descriptive model via expanded input parameters.

Each approach has advantages and disadvantages. The individual simulations of the first would be simpler than the more complex simulation of the second. As a consequence, first approach simulations would be easier to develop and program and probably would be slightly less expensive to run. On the other hand, it would be much easier to provide software support and maintenance for one more complex simulation than for several smaller ones.

Probably, a wider range of local office configurations could be represented through the first alternative, but the manager would be likely to become familiar with only that simulation most closely representing the current configuration of his office. If he were to use the more flexible simulation of the second approach, he would be more likely to investigate a wider range of alternative office configurations.

The more general simulation of the second alternative appears to be the better choice.

The effect of simulation on local office management is limited only by the ingenuity of the local office manager. He can use it

to investigate a wide assortment of problems. In addition to determining the most effective way to change system behavior, the use of simulation to find a more cost-effective way of producing the same system behavior should not be overlooked. In particular, the effect of increased computer usage on cost and service levels can be explored.

Simulation can also provide valuable inputs to the policy development process, particularly in the area of budget estimates. The cost of policy decisions can be evaluated before implementation. This use has the added advantage of forcing fairly detailed planning of the changes required before possibly expensive implementation programs are begun. Simulation is the most cost-effective way of providing these evaluations.

Chapter 4 illustrated how a simulation can be used by a local office manager or planner. Before any further work is attempted, it would be desirable to identify a group of office managers willing to use the simulation tool. The simulation should be modified to fit the circumstances of their offices; and the cost of adapting the model to each office, the use the managers make of it, and the benefits accruing from it should be recorded.

However, implementing a model requires more than just turning over computer programs to a user. It requires interaction between systems analysts and users to identify problems, train users, and interact with solutions.

APPENDIX A

Example Simulation Output

TABLE A-1. INPUT REPORT

RUN 5

****
* INPUT REPORT *
****

ARRIVAL RATES

HOUR	NEW APPS MEAN	OLD APPS MEAN	JOB ORDER FROM	JOB ORDER TO
8	1.824	0.949	0.0	20.000
9	1.749	0.840	0.0	20.000
10	0.926	0.553	0.0	20.000
11	1.348	1.025	0.0	20.000
12	1.940	1.577	0.0	20.000
1	1.500	1.160	0.0	20.000
2	4.350	1.406	0.0	20.000
3	1.532	1.720	0.0	20.000
4	6.640	3.720	0.0	20.000

ACTIVITY DURATIONS

HOUR	DISCUSSIONS RECEP MEAN	DISCUSSIONS EMP. OFF. FROM	DISCUSSIONS EMP. OFF. TO	APP JOB SEARCH SUCCESSFUL FROM	APP JOB SEARCH SUCCESSFUL TO	APP JOB SEARCH UNSUCCESSFUL FROM	APP JOB SEARCH UNSUCCESSFUL TO
8	0.300	0.0	19.200	11.600	32.000	15.600	26.700
9	0.300	0.0	19.200	11.600	32.000	15.600	26.700
10	0.300	0.0	19.200	11.600	32.000	15.600	26.700
11	0.300	0.0	19.200	11.600	32.000	15.600	26.700
12	0.300	0.0	19.200	11.600	32.000	15.600	26.700
1	0.300	0.0	19.200	11.600	32.000	15.600	26.700
2	0.300	0.0	19.200	11.600	32.000	15.600	26.700
3	0.300	0.0	19.200	11.600	32.000	15.600	26.700
4	0.300	0.0	19.200	11.600	32.000	15.600	26.700

ACTIVITY DURATIONS

HOUR	TERMINAL USE RECEPTIONIST FROM	TERMINAL USE RECEPTIONIST TO	TERMINAL USE EMP. OFF. FROM	TERMINAL USE EMP. OFF. TO	JOBORDER FROM	JOBORDER TO	MISC. TASK FROM	MISC. TASK TO
8	0.250	0.750	0.500	2.500	0.0	4.000	1.000	1.000
9	0.250	0.750	0.500	2.500	0.0	4.000	1.000	1.000
10	0.250	0.750	0.500	2.500	0.0	4.000	1.000	1.000
11	0.250	0.750	0.500	2.500	0.0	4.000	1.000	1.000
12	0.250	0.750	0.500	2.500	0.0	4.000	1.000	1.000
1	0.250	0.750	0.500	2.500	0.0	4.000	1.000	1.000
2	0.250	0.750	0.500	2.500	0.0	4.000	1.000	1.000
3	0.250	0.750	0.500	2.500	0.0	4.000	1.000	1.000
4	0.250	0.750	0.500	2.500	0.0	4.000	1.000	1.000

CAPACITIES

HOUR	RECEP	EMPOF	TERM
8	2	13	4
9	2	15	4
10	3	20	4
11	2	20	4
12	1	15	4
1	2	17	4
2	1	17	4
3	1	12	4
4	1	8	4

TABLE A-2. APPLICANTS

RUN 5

*** APPLICANTS ***

TIME	CLASS	ARRIVALS	APPLICANTS IN SYSTEM MIN	MAX	AVERAGE	DONE	APPLICANT TIME SPENT IN SYSTEM MIN	MAX	MEAN	STD DEV
8- 9	ALL	97	0	41	29.108	66	2.732	43.316	20.028	10.544
	NEW	37	0	23	14.316	19	24.464	41.255	32.282	5.111
	OLD	43	0	14	10.360	37	2.732	43.316	14.060	8.029
	OTH	17	0	8	4.432	10	11.767	26.071	18.828	5.271
9-10	ALL	86	25	44	33.071	82	2.685	45.471	32.574	11.042
	NEW	24	11	20	16.071	29	24.076	41.705	32.036	5.797
	OLD	47	4	21	12.695	37	2.685	45.471	16.625	10.410
	OTH	15	2	7	4.306	16	12.800	26.422	17.548	3.710
10-11	ALL	140	32	66	45.808	112	1.811	45.684	21.846	10.953
	NEW	58	10	37	25.170	36	20.990	40.908	32.369	5.371
	OLD	59	8	25	13.248	54	1.811	45.684	15.794	10.375
	OTH	23	4	12	7.390	22	11.250	24.855	19.478	4.945
11-12	ALL	90	36	64	51.693	113	7.009	55.204	28.202	12.201
	NEW	31	19	35	27.110	45	28.237	48.105	38.184	5.859
	OLD	44	12	25	20.111	52	7.009	55.204	23.132	11.601
	OTH	15	2	7	4.471	16	11.423	26.075	16.605	4.651
12- 1	ALL	62	20	41	26.831	79	5.446	49.260	26.172	11.833
	NEW	21	6	22	13.849	34	25.647	48.457	36.101	5.794
	OLD	33	6	17	10.734	36	5.446	49.260	18.862	10.239
	OTH	8	0	6	2.247	9	11.148	25.682	17.909	5.648
1- 2	ALL	99	21	48	32.639	79	2.524	48.493	20.444	11.098
	NEW	35	8	24	15.788	21	23.254	46.352	30.371	5.953
	OLD	55	5	24	13.636	46	2.524	48.493	16.281	11.360
	OTH	9	0	6	3.214	12	11.950	24.038	19.033	4.273
2- 3	ALL	63	25	46	35.619	80	7.183	53.563	29.787	11.499
	NEW	17	8	24	15.124	28	29.351	53.563	40.325	5.851
	OLD	36	10	25	17.414	45	7.183	50.167	24.605	10.187
	OTH	10	1	5	3.081	7	16.317	24.468	20.947	3.863
3- 4	ALL	63	22	31	26.981	60	3.921	44.528	26.336	11.245
	NEW	38	11	24	18.995	29	23.557	44.528	34.607	6.050
	OLD	15	1	10	4.276	20	3.921	44.445	18.096	11.339
	OTH	10	1	5	3.710	11	12.090	25.626	19.514	3.730
4- 5	ALL	26	8	30	15.307	44	6.292	47.510	28.421	12.136
	NEW	8	4	20	9.599	23	26.862	47.510	37.478	6.106
	OLD	13	1	7	4.305	14	6.292	35.022	18.832	10.088
	OTH	5	0	4	1.402	7	11.200	26.657	17.840	6.223
8-5	ALL	726	0	66	33.006	715	11.200	55.204	24.759	11.859
8-5	NEW	269	0	37	17.336	264	20.990	53.563	35.273	6.437
8-5	OLD	345	0	25	11.864	38[illegible]	1.811	55.204	18.627	10.965
8-5	OTH	112	0	12	3.806	11[illegible]	11.148	26.422	18.536	4.663

TABLE A-3. RECEPTIONIST FACILITY

RUN 5

RECEPTIONIST FACILITY

TIME	STAFF LEVEL	ACTIVITY	AVG STAFF UTILIZATION	NO. OF TRANSACTION AVG	MAX	TOTAL	TIME PER TRANSACTION MEAN	STD DEV
8- 9	2	RECEPTION	0.480	0.960	2	69	0.644	0.455
		ENCOUNTER	0.291	0.582	2	105	0.327	0.338
		TERM WAIT	0.012	0.024	1	6	0.243	0.145
		COMPUTER	0.177	0.354	2	43	0.494	0.148
		MISC.	0.520					
		HR SUB-TOTAL	1.000					
9-10	2	RECEPTION	0.562	1.124	2	92	0.629	0.504
		ENCOUNTER	0.364	0.727	2	117	0.378	0.420
		TERM WAIT	0.010	0.020	1	6	0.199	0.183
		COMPUTER	0.189	0.377	2	47	0.481	0.155
		MISC.	0.438					
		HR SUB-TOTAL	1.000					
10-11	3	RECEPTION	0.453	1.358	3	109	0.575	0.480
		ENCOUNTER	0.254	0.762	3	167	0.274	0.293
		TERM WAIT	0.044	0.131	2	20	0.393	0.305
		COMPUTER	0.155	0.465	2	59	0.472	0.147
		MISC.	0.547					
		HR SUB-TOTAL	1.000					
11-12	2	RECEPTION	0.573	1.147	2	99	0.604	0.555
		ENCOUNTER	0.326	0.653	2	131	0.298	0.322
		TERM WAIT	0.069	0.138	2	14	0.590	0.327
		COMPUTER	0.178	0.356	2	43	0.496	0.167
		MISC.	0.427					
		HR SUB-TOTAL	1.000					
12- 1	1	RECEPTION	0.665	0.665	2	62	0.560	0.425
		ENCOUNTER	0.352	0.352	1	82	0.258	0.249
		TERM WAIT	0.047	0.047	1	5	0.564	0.431
		COMPUTER	0.266	0.266	1	33	.481	0.132
		MISC.	0.335					
		HR SUB-TOTAL	1.000					

TABLE A-3. Continued

RECEPTIONIST FACILITY

TIME	STAFF LEVEL	ACTIVITY	AVG STAFF UTILIZATION	NO. OF TRANSACTION AVG	MAX	TOTAL	TIME PER TRANSACTION MEAN	STD DEV
1- 2	2	RECEPTION	0.592	1.184	2	93	0.669	0.437
		ENCOUNTER	0.331	0.662	2	128	0.310	0.265
		TERM WAIT	0.023	0.045	2	9	0.302	0.196
		COMPUTER	0.238	0.477	2	56	0.513	0.151
		MISC.	0.408					
		HR SUB-TOTAL	1.000					
2- 3	1	RECEPTION	0.788	0.788	1	65	0.660	0.535
		ENCOUNTER	0.422	0.422	1	82	0.309	0.247
		TERM WAIT	0.056	0.056	1	4	0.845	0.405
		COMPUTER	0.309	0.309	1	36	0.516	0.156
		MISC.	0.212					
		HR SUB-TOTAL	1.000					
3- 4	1	RECEPTION	0.527	0.527	1	53	0.401	0.335
		ENCOUNTER	0.399	0.399	1	90	0.266	0.244
		TERM WAIT	0.0	0.0	0	0	0.0	0.0
		COMPUTER	0.128	0.128	1	15	0.513	0.142
		MISC.	0.473					
		HR SUB-TOTAL	1.000					
4- 5	1	RECEPTION	0.260	0.260	1	28	0.497	0.350
		ENCOUNTER	0.139	0.139	1	37	0.227	0.186
		TERM WAIT	0.0	0.0	0	0	0.0	0.0
		COMPUTER	0.121	0.121	1	13	0.557	0.092
		MISC.	0.740					
		HR SUB-TOTAL	1.000					
8-5		RECEPTION	0.545	0.890	3	670	0.597	0.476
8-5		ENCOUNTER	0.320	0.522	3	939	0.300	0.304
8-5		TERM WAIT	0.029	0.051	2	64	0.433	0.329
8-5		COMPUTER	0.196	0.317	2	345	0.496	0.149
		MISC.	0.455					
8-5	1.87*	---TOTAL---	1.000					

TABLE A-4. RECEPTIONIST QUEUE

RUN 5

****
* RECEPTIONIST QUEUE *
****

	----- QUEUE CONTENTS -----					
TIME	ENTRIES	ENTRIES*	MIN	MAX	AVERAGE	NOW
8- 9	106	40	0	7	0.417	0
9-10	116	48	0	4	0.298	0
10-11	167	45	0	12	0.511	0
11-12	132	57	0	9	0.875	0
12- 1	81	44	0	7	0.856	1
1- 2	128	67	0	5	0.572	0
2- 3	82	62	0	6	1.675	0
3- 4	91	47	0	7	0.554	1
4- 5	36	12	0	2	0.065	0
8-5	939	422	0	12	0.647	

ENTRIES* INCLUDES ONLY NON-ZERO QUEUE TIMES

	----- QUEUE WAITING TIMES -----							
TIME	MIN	ZERO-#	ZERO-%	MAX	MEAN	STD DEV	MEAN*	STD DEV*
8- 9	0.015	66	62.26	1.738	0.236	0.430	0.625	0.498
9-10	0.001	68	58.62	1.866	0.154	0.334	0.373	0.435
10-11	0.007	122	73.05	1.760	0.184	0.429	0.682	0.590
11-12	0.009	75	56.82	2.508	0.398	0.659	0.921	0.724
12- 1	0.015	37	45.68	3.447	0.629	0.929	1.157	0.989
1- 2	0.040	61	47.66	1.060	0.272	0.344	0.519	0.311
2- 3	0.018	20	24.39	5.030	1.225	1.370	1.621	1.357
3- 4	0.057	44	48.35	1.570	0.364	0.496	0.705	0.486
4- 5	0.167	24	66.67	0.793	0.111	0.192	0.333	0.191
8-5	0.001	517	0.0	5.030	0.372	0.701	0.828	0.847

MEAN* AND STD DEV* ARE FOR NON-ZERO TIMES ONLY

TABLE A-5. EMPLOYMENT OFFICER FACILITY

RUN 5

= EMPLOYMENT OFFICER =
= FACILITY =

TIME	STAFF LEVEL	ACTIVITY	AVG STAFF UTILIZATION	NO. OF TRANSACTION AVG	MAX	TOTAL	TIME PER TRANSACTION MEAN	STD DEV
1- 2	17	INTERVIEW	0.686	11.656	17	67	10.119	5.663
		DISCUSSION	0.587	9.980	16	68	8.441	5.559
		TERM WAIT	0.005	0.085	2	19	0.269	0.197
		COMPUTER	0.094	1.591	4	67	1.427	0.584
		JOB ORDER	0.011	0.182	1	7	1.828	1.141
		MISC.	0.304	5.162	12	311	1.000	0.0
		HR SUB-TOTAL	1.000					
2- 3	17	INTERVIEW	0.948	16.123	17	73	13.165	5.731
		DISCUSSION	0.820	13.944	17	74	11.576	5.699
		TERM WAIT	0.009	0.146	3	14	0.605	0.407
		COMPUTER	0.120	2.034	4	73	1.652	0.620
		JOB ORDER	0.012	0.203	1	5	2.296	1.501
		MISC.	0.040	0.673	5	38	1.000	0.0
		HR SUB-TOTAL	1.000					
3- 4	12	INTERVIEW	0.761	9.126	12	49	12.124	5.263
		DISCUSSION	0.656	7.867	12	46	10.497	5.470
		TERM WAIT	0.001	0.007	1	1	0.684	0.0
		COMPUTER	0.104	1.252	4	49	1.591	0.568
		JOB ORDER	0.016	0.195	1	5	2.481	0.812
		MISC.	0.226	2.710	7	165	1.000	0.0
		HR SUB-TOTAL	1.003					
4- 5	8	INTERVIEW	0.865	6.923	12	37	11.799	6.033
		DISCUSSION	0.746	5.966	10	37	10.206	5.950
		TERM WAIT	0.001	0.005	1	2	0.136	0.152
		COMPUTER	0.119	0.952	4	37	1.571	0.613
		JOB ORDER	0.024	0.195	1	10	1.168	1.137
		MISC.	0.126	1.010	4	58	1.000	0.0
		HR SUB-TOTAL	1.01o					
8-5		INTERVIEW	0.835	12.772	20	605	11.323	5.693
8-5		DISCUSSION	0.718	10.982	20	607	9.738	5.668
8-5		TERM WAIT	0.005	0.091	4	123	0.400	0.372
8-5		COMPUTER	0.112	1.699	4	605	1.516	0.591
8-5		JOB ORDER	0.014	0.200	1	58	1.861	1.187
8-5		MISC.	0.154	2.286	13	1232	1.000	0.001
8-5	17.12*	---TOTAL---	1.003					

* - AVERAGE STAFF LEVEL IS IN 8-HOUR MAN DAYS

TABLE A-5 Continued

EMPLOYMENT OFFICER FACILITY

TIME	STAFF LEVEL	ACTIVITY	AVG STAFF UTILIZATION	NO. OF TRANSACTION AVG	MAX	TOTAL	TIME PER TRANSACTION MEAN	STD DEV
8- 9	13	INTERVIEW	0.758	9.853	13	56	9.996	5.561
		DISCUSSION	0.654	8.502	13	57	8.493	5.603
		TERM WAIT	0.002	0.025	2	9	0.168	0.120
		COMPUTER	0.102	1.326	4	56	1.420	0.587
		JOB ORDER	0.016	0.209	1	6	2.094	1.257
		MISC.	0.226	2.938	13	172	1.000	0.0
		HR SUB-TOTAL	1.000					
9-10	15	INTERVIEW	0.853	12.800	15	66	10.378	5.903
		DISCUSSION	0.783	11.141	15	67	9.177	5.965
		TERM WAIT	0.000	0.001	1	3	0.021	0.027
		COMPUTER	0.110	1.657	4	66	1.487	0.623
		JOB ORDER	0.014	0.205	1	7	1.754	1.199
		MISC.	0.133	1.996	11	124	1.000	0.0
		HR SUB-TOTAL	1.000					
10-11	20	INTERVIEW	0.768	15.359	20	90	10.387	5.951
		DISCUSSION	0.657	13.144	20	90	8.731	5.821
		TERM WAIT	0.007	0.136	3	26	0.314	0.236
		COMPUTER	0.104	2.080	4	90	1.398	0.602
		JOB ORDER	0.010	0.191	1	8	1.431	1.085
		MISC.	0.222	4.450	12	267	1.000	0.0
		HR SUB-TOTAL	1.000					
11-12	20	INTERVIEW	0.989	19.783	20	97	11.622	5.538
		DISCUSSION	0.848	16.967	20	96	9.913	5.558
		TERM WAIT	0.014	0.280	3	36	0.467	0.393
		COMPUTER	0.127	2.535	4	97	1.571	0.592
		JOB ORDER	0.011	0.217	1	5	2.606	0.719
		MISC.	0.0	0.0	0	0	0.0	0.0
		HR SUB-TOTAL	1.000					
12- 1	15	INTERVIEW	0.888	13.323	20	70	12.489	4.917
		DISCUSSION	0.755	11.326	19	72	10.879	4.827
		TERM WAIT	0.009	0.135	4	13	0.623	0.583
		COMPUTER	0.124	1.861	4	70	1.557	0.495
		JOB ORDER	0.013	0.202	1	5	2.049	1.573
		MISC.	0.109	1.638	5	97	1.000	0.001
		HR SUB-TOTAL	1.011					

TABLE A-6. INTERVIEW QUEUE

RUN 5

= INTERVIEW QUEUE =

	QUEUE CONTENTS					
TIME	ENTRIES	ENTRIES*	MIN	MAX	AVERAGE	NOW
8- 9	62	62	0	5	1.180	0
9-10	75	75	0	9	1.712	6
10-11	95	95	0	13	1.357	11
11-12	97	97	1	19	8.710	3
12- 1	60	60	0	8	1.239	0
1- 2	74	74	0	12	1.210	10
2- 3	68	68	0	15	6.105	0
3- 4	49	49	0	2	0.210	1
4- 5	29	29	0	7	2.159	0
8-5	609	609	0	19	2.654	

ENTRIES* INCLUDES ONLY NON-ZERO QUEUE TIMES

	QUEUE WAITING TIMES							
TIME	MIN	ZERO-#	ZERO-%	MAX	MEAN	STD DEV	MEAN*	STD DEV*
8- 9	0.002	0	0.0	6.400	1.142	1.384	1.142	1.384
9-10	0.015	0	0.0	5.672	1.179	1.480	1.179	1.480
10-11	0.003	0	0.0	3.400	0.781	1.059	0.781	1.059
11-12	2.176	0	0.0	9.388	5.576	2.180	5.576	2.180
12- 1	0.004	0	0.0	6.922	1.292	1.936	1.292	1.936
1- 2	0.002	0	0.0	4.811	0.682	1.196	0.682	1.196
2- 3	0.008	0	0.0	12.116	5.712	3.792	5.712	3.792
3- 4	0.010	0	0.0	1.635	0.256	0.295	0.256	0.295
4- 5	0.008	0	0.0	14.860	4.469	4.029	4.469	4.029
8-5	0.002	0	0.0	14.860	2.353	2.984	2.353	2.984

MEAN* AND STD DEV* ARE FOR NON-ZERO TIMES ONLY

TABLE A-7. TERMINAL FACILITY

RUN 5

TERMINAL FACILITY

TIME	UNITS	USERS	AVERAGE UTILIZATION	NO. OF TRANSACTIONS AVG	MAX	TOTAL	TIME PER TRANSACTION MIN	MAX	MEAN	STD DEV
8- 9	4	ALL USER	0.420	1.680	4	99	0.257	2.464	1.017	0.635
		EMPOF	0.331	1.326	4	56	0.519	2.464	1.420	0.587
		RECEP	0.088	0.354	2	43	0.257	0.741	0.494	0.148
		FREE	0.580							
9-10	4	ALL USER	0.509	2.034	4	113	0.252	2.495	1.069	0.695
		EMPOF	0.414	1.657	4	66	0.506	2.495	1.487	0.623
		RECEP	0.094	0.377	2	47	0.252	0.730	0.481	0.155
		FREE	0.491							
10-11	4	ALL USER	0.636	2.544	4	149	0.250	2.417	1.031	0.658
		EMPOF	0.520	2.080	4	90	0.500	2.417	1.398	0.602
		RECEP	0.116	0.465	2	59	0.250	0.749	0.472	0.147
		FREE	0.364							
11-12	4	ALL USER	0.723	2.892	4	140	0.250	2.450	1.241	0.706
		EMPOF	0.634	2.535	4	97	0.507	2.450	1.571	0.592
		RECEP	0.089	0.356	2	43	0.250	0.729	0.496	0.167
		FREE	0.277							
12- 1	4	ALL USER	0.532	2.127	4	103	0.253	2.365	1.212	0.653
		EMPOF	0.465	1.861	4	70	0.520	2.365	1.557	0.495
		RECEP	0.066	0.266	1	33	0.253	0.721	0.481	0.132
		FREE	0.468							
1- 2	4	ALL USER	0.517	2.068	4	123	0.252	2.490	1.011	0.635
		EMPOF	0.398	1.591	4	67	0.522	2.490	1.427	0.584
		RECEP	0.119	0.477	2	56	0.252	0.738	0.513	0.151
		FREE	0.483							
2- 3	4	ALL USER	0.586	2.343	4	109	0.263	2.486	1.276	0.743
		EMPOF	0.508	2.034	4	73	0.507	2.486	1.652	0.620
		RECEP	0.077	0.309	1	36	0.263	0.736	0.516	0.156
		FREE	0.414							
3- 4	4	ALL USER	0.345	1.380	4	64	0.287	2.486	1.338	0.680
		EMPOF	0.313	1.252	4	49	0.577	2.486	1.591	0.558
		RECEP	0.032	0.128	1	15	0.287	0.663	0.513	0.142
		FREE	0.655							
4- 5	4	ALL USER	0.268	1.073	4	50	0.434	2.479	1.308	0.693
		EMPOF	0.238	0.952	4	37	0.562	2.479	1.571	0.613
		RECEP	0.030	0.121	1	13	0.434	0.712	0.557	0.092
		FREE	0.732							
8-5	4	ALL USER	0.504	2.016	4	950	0.250	2.495	1.146	0.686
8-5	4	EMPOF	0.425	1.699	4	605	0.500	2.495	1.516	0.591
8-5	4	RECEP	0.079	0.317	2	345	0.250	0.749	0.496	0.149
8-5	4	FREE	0.496							

TABLE A-8. TERMINAL QUEUE

RUN 5

* TERMINAL QUEUE *

TIME	USERS	QUEUE CONTENTS ENTRIES	ENTRIES*	MIN	MAX	AVERAGE	NOW
8- 9	ALL USER	100	15	0	2	0.049	0
	EMPOF	57	9	0	2	0.025	0
	RECEP	43	6	0	1	0.024	0
9-10	ALL USER	114	9	0	1	0.021	0
	EMPOF	67	3	0	1	0.001	0
	RECEP	47	6	0	1	0.020	0
10-11	ALL USER	149	46	0	3	0.267	0
	EMPOF	90	26	0	3	0.136	0
	RECEP	59	20	0	2	0.131	0
11-12	ALL USER	140	50	0	4	0.418	0
	EMPOF	96	36	0	3	0.280	0
	RECEP	44	14	0	2	0.138	0
12- 1	ALL USER	105	18	0	4	0.182	0
	EMPOF	72	13	0	4	0.135	0
	RECEP	33	5	0	1	0.047	0
1- 2	ALL USER	123	28	0	2	0.130	0
	EMPOF	68	19	0	2	0.085	0
	RECEP	55	9	0	2	0.045	0
2- 3	ALL USER	109	18	0	3	0.202	1
	EMPOF	73	14	0	3	0.146	1
	RECEP	36	4	0	1	0.056	0
3- 4	ALL USER	62	1	0	1	0.007	0
	EMPOF	47	1	0	1	0.007	0
4- 5	ALL USER	50	2	0	1	0.005	0
	EMPOF	37	2	0	1	0.005	0
8-5	ALL USER	952	187	0	4	0.142	
8-5	EMPOF	607	123	0	4	0.091	
8-5	RECEP	317	64	0	2	0.051	

ENTRIES* INCLUDES ONLY NON-ZERO QUEUE TIMES

TABLE A-8. Continued

TIME	USER	QUEUE WAITING TIMES MIN	ZERO-#	ZERO-%	MAX	MEAN	STD DEV	MEAN*	STD DEV*
8- 9	ALL USER	0.004	85	85.00	0.433	0.030	0.086	0.198	0.131
	EMPOF	0.004	48	84.21	0.355	0.026	0.077	0.168	0.120
	RECEP	0.035	37	86.05	0.433	0.034	0.099	0.243	0.145
9-10	ALL USER	0.005	105	92.11	0.506	0.011	0.059	0.140	0.171
	EMPOF	0.005	64	95.52	0.053	0.001	0.006	0.021	0.027
	RECEP	0.033	41	87.23	0.506	0.025	0.090	0.199	0.183
10-11	ALL USER	0.003	103	69.13	1.119	0.107	0.219	0.348	0.268
	EMPOF	0.004	64	71.11	0.854	0.091	0.190	0.314	0.236
	RECEP	0.003	39	66.10	1.119	0.133	0.256	0.393	0.305
11-12	ALL USER	0.019	90	64.29	1.494	0.179	0.329	0.501	0.377
	EMPOF	0.019	60	62.50	1.494	0.175	0.330	0.467	0.393
	RECEP	0.055	30	68.18	1.109	0.188	0.331	0.590	0.327
12- 1	ALL USER	0.022	87	82.86	1.652	0.104	0.315	0.607	0.533
	EMPOF	0.028	59	81.94	1.652	0.112	0.340	0.623	0.583
	RECEP	0.022	28	84.85	1.133	0.086	0.256	0.564	0.431
1- 2	ALL USER	0.023	95	77.24	0.736	0.064	0.149	0.280	0.194
	EMPOF	0.023	49	72.06	0.736	0.075	0.159	0.269	0.197
	RECEP	0.075	46	83.64	0.612	0.049	0.136	0.302	0.196
2- 3	ALL USER	0.030	91	83.49	1.357	0.109	0.294	0.658	0.407
	EMPOF	0.030	59	80.82	1.357	0.116	0.296	0.605	0.407
	RECEP	0.415	32	88.89	1.233	0.094	0.294	0.845	0.405
3- 4	ALL USER	0.684	61	98.39	0.684	0.011	0.087	0.684	0.0
	EMPOF	0.684	46	97.87	0.684	0.015	0.100	0.684	0.0
	RECEP	0.0	15	100.00	0.0	0.0	0.0	0.0	0.0
4- 5	ALL USER	0.029	48	96.00	0.243	0.005	0.035	0.136	0.152
	EMPOF	0.029	35	94.59	0.243	0.007	0.040	0.136	0.152
	RECEP	0.0	13	100.00	0.0	0.0	0.0	0.0	0.0
8-5	ALL USER	0.003	765	80.36	1.652	0.081	0.227	0.411	0.358
8-5	EMPOF	0.004	484	79.74	1.652	0.081	0.232	0.400	0.372
8-5	RECEP	0.0	281	81.45	1.233	0.080	0.219	0.433	0.329

MEAN* AND STD DEV* ARE FOR NON-ZERO TIMES ONLY

USER	TOTAL QUEUE WAITING TIME HOURS	% OF AVAILABLE TIME
ALL USER	1.281	0.843
EMPOF	0.166	0.121
RECEP	0.426	2.843

TABLE A-9. JOB ORDER QUEUE

RUN 5

*** JOB ORDER QUEUE ***

----- QUEUE CONTENTS -----

TIME	ENTRIES	ENTRIES*	MIN	MAX	AVERAGE	NOW
8- 9	6	6	0	1	0.040	0
9-10	7	7	0	1	0.023	0
10-11	8	8	0	1	0.040	0
11-12	5	5	0	1	0.027	0
12- 1	6	6	0	1	0.023	0
1- 2	6	6	0	1	0.016	0
2- 3	6	6	0	1	0.050	0
3- 4	4	4	0	1	0.023	0
4- 5	10	10	0	4	0.432	1
8-5	58	58	0	4	0.075	

ENTRIES* INCLUDES ONLY NON-ZERO QUEUE TIMES

----- QUEUE WAITING TIMES -----

TIME	MIN	ZERO-#	ZERO-%	MAX	MEAN	STD DEV	MEAN*	STD DEV*
8- 9	0.039	0	0.0	1.000	0.402	0.406	0.402	0.406
9-10	0.032	0	0.0	0.458	0.197	0.147	0.197	0.147
10-11	0.035	0	0.0	0.711	0.302	0.280	0.302	0.280
11-12	0.081	0	0.0	0.717	0.322	0.254	0.322	0.254
12- 1	0.158	0	0.0	0.361	0.235	0.081	0.235	0.081
1- 2	0.006	0	0.0	0.583	0.159	0.219	0.159	0.219
2- 3	0.039	0	0.0	1.132	0.504	0.425	0.504	0.425
3- 4	0.005	0	0.0	0.699	0.352	0.400	0.352	0.400
4- 5	0.041	0	0.0	7.832	2.555	2.700	2.555	2.700
8-5	0.005	0	0.0	7.832	0.693	1.398	0.693	1.398

MEAN* AND STD DEV* ARE FOR NON-ZERO TIMES ONLY

APPENDIX B

RANDOM NUMBER GENERATION

A simulation like the local office simulation must reflect the existence of random processes such as the arrival of applicants. In a mathematical model of such a process, the time between applicant arrivals might be represented with a variable, say T. T would be a random variable with many possible values, each expressing a time interval between two successive arrivals. The set of all occurences of T, of every interarrival time, is called its population. Probability theory and statistics allow the drawing of inferences about a population from a randomly chosen subset, or sample, of the population.

For example, if the result of flipping a coin 10,000 times is 5020 heads and 4980 tails, we could infer that the probability of the next flip being heads is close to 0.502. Suppose, however, that the result of flipping a coin five times is four heads and one tail. Given only that sample, the best estimate of the probability of a head on the next flip is 0.8. However, since the sample size is so small, one cannot statistically reject (with any certainty) the hypothesis that the true probability is 0.5. In other words, if the sample size is small, the range of values to which the true value of a statistic estimated from the sample can confidently be limited is correspondingly large.

This same phenomena occurs in the simulation. Samples are drawn from many separate populations. The interarrival time sample is the single most important source of error, but many other sources of bias in the system can be traced to small numbers.

The method used to draw sample values, e.g., interarrival times, from larger populations compounds the problem. Given a random number between zero and one, a random sample value can be generated for any of the populations used in the simulation. Since a digital computer is a deterministic device, generating a truly random number can be a problem.

Techniques for making close approximations of random behavio. have been developed, however. Computer programs which can take an initial starting number, a "seed", and generate a number in the interval (0,1) and a new seed are available. They are called pseudo-random number generators or, simply, random number generators.

By successively invoking a random number generator, a stream of random numbers can be generated. The stream generated is deterministic in the sense that given the same initial seed the random number generator will always reproduce that stream; but if a large stream is generated, i.e., if the sample size is large enough, the stream (sample) will display characteristics very similar to those of a population with a uniform distribution in the interval (0,1) and will be relatively independent of the initial seed.

In most cases, however, the nature of this model causes the samples used in the simulation to be relatively small; for example, the number of new applicant arrivals in one day is relatively small. As a consequence, the arbitrary choice of the random number generator's initial seed significantly affects simulation output, i.e., errors in the estimates of the parameters will naturally be reflected in the behavior of the simulated system.

To simplify the presentation of the example in Chapter 4, this problem was ignored; but techniques to overcome this problem are available.

First, the local office day could be simulated several times using different initial random number seeds, and an average simulation result could then be calculated. This average would be much more representative of actual system behavior.

A second technique, used in conjunction with the first, deals with removal of bias in the generation of random numbers. A first simulation uses the usual random number generator. Then, without changing the initial seeds, a second simulation uses a modified version of the usual random number generator.

This modified version can be described as follows: if, for a

given seed, the usual random number generator calculates a number, say R, ($0 \leq R \leq 1$), the modified version produces the number 1-R. Thus if the first random number stream is biased to the low side, the second stream is biased to the high side. When the results are averaged, the deviation from the mean is removed.

It should be noted that the effects of taking a small sample from a large population will also be exhibited in the true system. The behavior of the local office system will also vary from day to day. The fact that the simulation does not show overloading for a given resource allocation does not imply that overloading will never occur. Natural variances in system behavior can cause overloading. For example, the average interarrival time on any given day may be smaller (i.e. applicants will arrive in larger numbers) simply due to the random nature of the process. Such random occurrences could increase the system load. The local office manager should keep this in mind when using the simulation to fine tune his resource allocations.